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EDITORIAL STAFF

Editors

Mr. A. V. Tunison, Assistant Chief, Branch of Game-fish and Hatcheries, Fish and Wildlife Service.

Mr. W. F. Carbine, Branch of Fishery Biology, Fish and Wildlife Service.

Assistant Editor

Miss S. M. Mullin, Branch of Game-fish and Hatcheries, Fish and Wildlife Service.

Associate Editors

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Dr. R. E. Johnson, Fisheries Research Supervisor, Division of Game and Fish, Minnesota Department of Conservation, St. Paul, Minnesota.

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(See inside back cover)

The PROGRESSIVE FISH-CULTURIST

News and Views from many Sources on Practical Hatchery Problems

Volume 11 | Washington, D. C. | January 1949 | Number 1

TABLE OF CONTENTS

	Page
Muskellunge Fingerling Culture, by A. A. Oehmcke	3
Fish Culture in Morocco, by J. G. Prud'homme	19
Progress Report: Improvement of Fish-Cultural Practices in Oklahoma, by A. D. Aldrich	25
Survey of Fish Culture in the United States, by A. V. Tunison, S. M. Mullin, and O. L. Meehean	31
P. F.-C. Loses Editor--Elmer Higgins	70
P. F.-C. Gains Editor--"Fent" Carbine	71
Control of Crawfish, by Clay Lyle	72
Urethane (Ethyl carbamate) in Some Fishery Procedures, by S. D. Gerking	73
Fact and Fiction in Spawntaking: Addenda, by R. R. Rucker	75
Use of Lime in Acid Ponds, by M. C. Walker	78
Experimental Fish Troughs, by S. F. Snieszko	79
Neutralizing Chlorine in Trout Display Tanks, by E. O. Rodgers	82

From Publications

Reprint:

New Industry in Utah Utilizes Trash Fish	85

Abstract:

Effectiveness of Modern Fish Management Practices: Planting, by L. L. Smith, Jr.	87
Report of the Division of Fish Culture, by O. R. Kingsbury	87
Report of the Division of Aquatic Biology and Physics, by P. R. Needham	88
Observations on the Spawning Habits of Lake Trout (Cristivomer namaycush namaycush) in an Algonquin Park Lake, by N. V. Martin	88
Study of the Coefficients of Condition of Wild Brook Trout from the Upper Hunt Creek Drainage, Michigan, by D. S. Shetter	88
Observations of Smelt Spawning, South Bay, Manitoulin Island, 1948, by N. S. Baldwin	89
Movements of Quebec Shad as Demonstrated by Tagging, by V. D. Vladykov	89
Rates of Growth of Game and Pan Fish in Ohio, Their Practical Interpretation and Some Technical Problems Involved, by I. M. Evans	90

Changes in Growth Rates of Fishes Following Reduction in Population Densities Following Winterkill, by W. C. Beckman 90
Thirteen-Year Record of Fish Production from Meander Lake and Accompanying Variations in Fish Populations, by L. S. Roach 90
Fish Depth Distributional Study of Tygart Reservoir, West Virginia, by E. A. Seaman and R. F. Stephens 91
Growth Studies on Fish: Use of Hydraulic Presses in Making Scale Impressions, by J. T. Greenbank and D. J. O'Donnell 91
Fertilization of Natural Lakes in Michigan, by R. C. Ball 91
Fish Removal in an Effort to Increase Growth Rate of Fish in Impounded Waters, by J. D. Walker 91
Value of Various Sulfonamides in the Treatment of Furunculosis in Brook Trout (Salvelinus fontinalis), by S. F. Snieszko, J. S. Gutsell, and S. B. Friddle 92
Prophylaxis of Furunculosis in Brook Trout (Salvelinus fontinalis) by Oral Immunization and Sulfamerazine, by S. F. Snieszko and S. B. Friddle 92
Contribution to the Etiology of Ulcer Disease of Trout, by S. F. Snieszko and S. B. Friddle 93
Atomic Energy and Fishery and Wildlife Resources, by Elmer Higgins 93

Clearing House 94

Items

Diffusion of Oxygen in Fish Tanks 24
Creel Census Tags 30
Farm Ponds and Fish Development 30
Prolicks and Borsum, Inc. 84

MUSKELLUNGE FINGERLING CULTURE

PRODUCTION OF THE "MUSKIE" IN WISCONSIN

A. A. Oehmcke
Wisconsin Conservation Department
Woodruff, Wisconsin

IN RECENT years there has been an increasing demand for larger fish for stocking, the supposition being that such fish have a better chance of survival and growth than fry. For more than 50 years, most States have practiced the stocking of fry only because of a lack of information and facilities for rearing fish to fingerling or yearling size.

Although during the past 30 years a considerable amount of work has been done in rearing bass and trout to fingerling size, until about the past decade not much progress has been made in the rearing of muskellunge (Esox masquinongy masquinongy Mitchill) and wall-eyed pike (Stizostedion vitreum vitreum Mitchill). Reports from the States of Iowa (Speaker, 1938) and Minnesota (Smith, 1945) indicate considerable progress in rearing walleye fingerlings. According to MacKay and Werner (1934) and Elson (1941), the Province of Ontario has conducted research on muskellunge fingerling culture and has succeeded in producing muskellunge fingerlings economically on a small scale. The State of Wisconsin began experimenting with the rearing of fingerling muskellunge in the early 1900's, but not until 1941 was research initiated on rearing technique which resulted in the production of large numbers of fingerlings annually.

As previously reported by MacKay and Werner, food is one of the most important single factors in rearing muskellunge fingerlings. The experience of the Wisconsin Conservation Department's Fish Propagation Section has been that from the time the 10- or 12-day-old muskellunge fry is placed in a rearing pond until it is removed as an advanced fingerling, it will gradually consume many times its total body weight in fish per day.

EGG FERTILIZATION AND HATCHING

The Wisconsin method of fertilizing and incubating muskellunge eggs is similar to that used in the artificial propagation of trout. A small number of eggs are extruded from the female into a small shallow pan and fertilized immediately by adding sperm from the male (figure 1). Fresh water is added to the milt-egg mixture, and the pan is set aside to allow the eggs to harden. After 30 or 40 minutes of hardening, the eggs separate. These are then added to a common collection in a 15-quart enameled pail that contains fresh water.

Before these eggs are transported to the hatchery, they are washed thoroughly four or five times to be certain that they are free from all mucus and surplus milt.

At the hatchery a 32-ounce graduate is used to measure the quantity of eggs and then to introduce them into the 4-quart hatching jars (figures 2 and 3). Eggs of the muskellunge are the same size as those of the northern pike, the number per fluid quart ranging from about 45,000 to 50,000.

The eggs are incubated in standard glass hatching jars. The period of incubation ranges from 15 to 20 days, depending on the prevailing water temperature. In order to allocate the proper number of fry to each rearing pond, the

FIGURE 1.-- Artificial fertilization of muskellunge eggs.

FIGURE 2.-- Measuring quantities of muskellunge eggs.

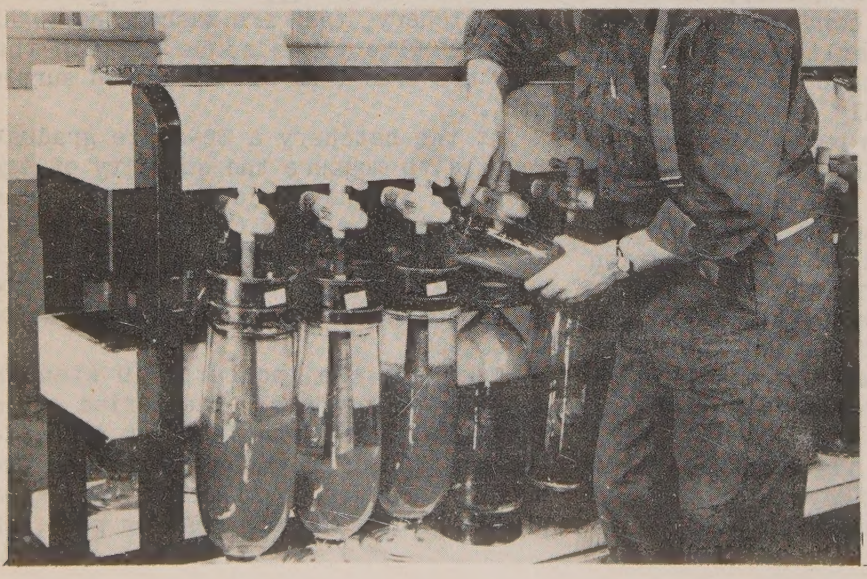

FIGURE 3.-- Filling hatching jars with measured muskellunge eggs.

(Photos by Wisconsin Conservation Department, Madison, Wisconsin)

FIGURE 4.-- Hatching muskellunge eggs and newly hatched fry.

(Photo by Wisconsin Conservation Department, Madison, Wisconsin)

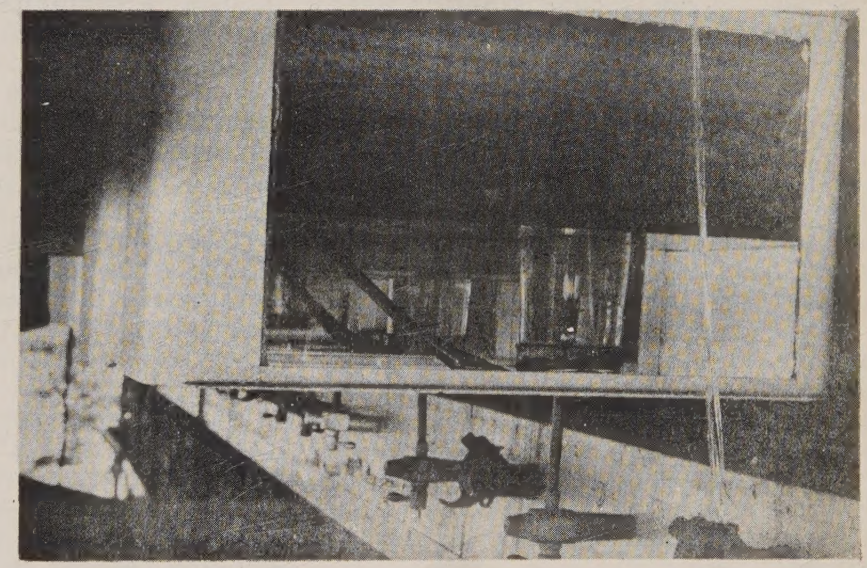

FIGURE 5.-- Pond-jar aquarium hatching unit.

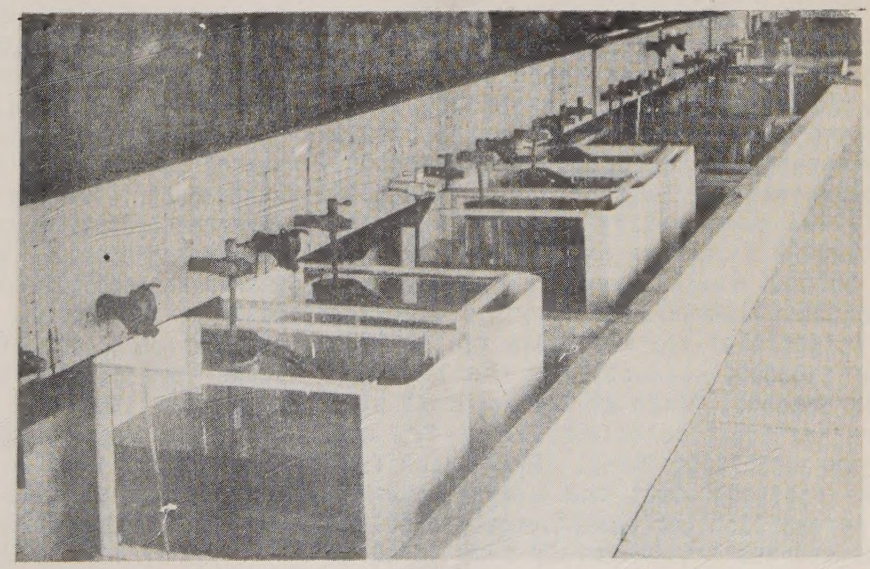

FIGURE 6.-- Battery of pond aquaria.

(Photos courtesy of author)

eggs are measured at the stage at which the embryo is well formed and the shell still firm. Each allotment is then placed in a separate jar that drains into an aquarium, into which the fry can swim and in which they can be held for the designated rearing pond (figures 4, 5, and 6). Swimming muskellunge fry begin to appear in the aquaria in approximately 11 to 15 days after they have been placed in the pond jars.

After they have been swimming up for at least 1-1/2 to 2 days in the pond aquaria, muskellunge fry are placed in the rearing ponds. After the fry have reached a strong swimming condition, they are carefully distributed on the surface of the rearing ponds by dipping from a large tub. A small duck skiff is used to reach all portions of the ponds.

POND PREPARATION

It has been learned by the Wisconsin muskellunge-culturists that, after food, the elimination of predatory fish and insects from rearing ponds is the next most important factor.

Taking cognizance of the fact that predators not only deplete the muskellunge population in the pond but also cause great inroads on the forage upon which the small muskellunge are dependent, culturists have given much attention to the proper preparation of rearing ponds before and after muskellunge and forage are introduced.

Rearing ponds which can be drained and dried thoroughly do not present a problem in Wisconsin; however, many of the muskellunge rearing ponds have small pockets which cannot be drained and which are capable of harboring minnows and insect larvae for long periods. To eliminate the possibility of carrying over predaceous fish from year to year, pockets in drained muskellunge ponds at Woodruff have been treated with varying strengths of rotenone at the beginning of the past four rearing seasons. In the 1942 and 1943 seasons, ponds at the Woodruff station were not poisoned before fry and forage were introduced. Production figures indicate that the average number of forage fish per muskellunge fingerling produced was approximately four to seven times greater in those years than in ensuing years when rotenone was applied (table 1).

From observations made during the 1942 and 1943 seasons, it was found that many stickleback minnows (Eucalia inconstans Kirtland) and dytiscid beetle larvae were present, and that these predators were instrumental in reducing large numbers of forage fish as well as in killing considerable quantities of muskellunge fingerlings. On many occasions the writer has observed advanced dytiscid larvae attacking and killing instantly 4- and 5-inch fingerlings.

Although rotenone applications cleaned out all stickleback minnows, it had no effect on dytiscid larvae. Therefore, in 1946, a variation of Meehean's kerosene and commercial fish-oil treatment (Meehean, 1937) was tried to control predaceous insects and larvae. Commercial furnace fuel oil was substituted for the kerosene and was applied directly to the surface of all the ponds at the Woodruff station. Most of the dytiscid larvae were killed by the first application, but the ponds that had heavy infestations were treated a second time. During the 1947 season few dytiscid larvae were observed and the oil treatment was limited to two ponds.

Sticklebacks were a problem only as long as the muskellunge fry--of small size and gregarious nature in shallow water at this time--were feeding on water fleas, Polyphemus, and other Cladocera. Plankton feeding in the ponds continued for 7 to 10 days, and it was quite apparent that sticklebacks could greatly reduce the number of muskellunge fry planted and were also responsible for consuming large amounts of sucker fry placed in the ponds as muskellunge forage (table 1). Many sticklebacks are inadvertently introduced when seined shiners are transported to the ponds to feed advanced fingerlings at the end of the first month of the rearing season. Observations made in 1947, when thousands of sticklebacks were planted in this manner, indicate that they are not predatory after the muskellunge fingerlings have reached a length of 2 or 3 inches. Many times muskellunge at this stage have been observed feeding on small sticklebacks.

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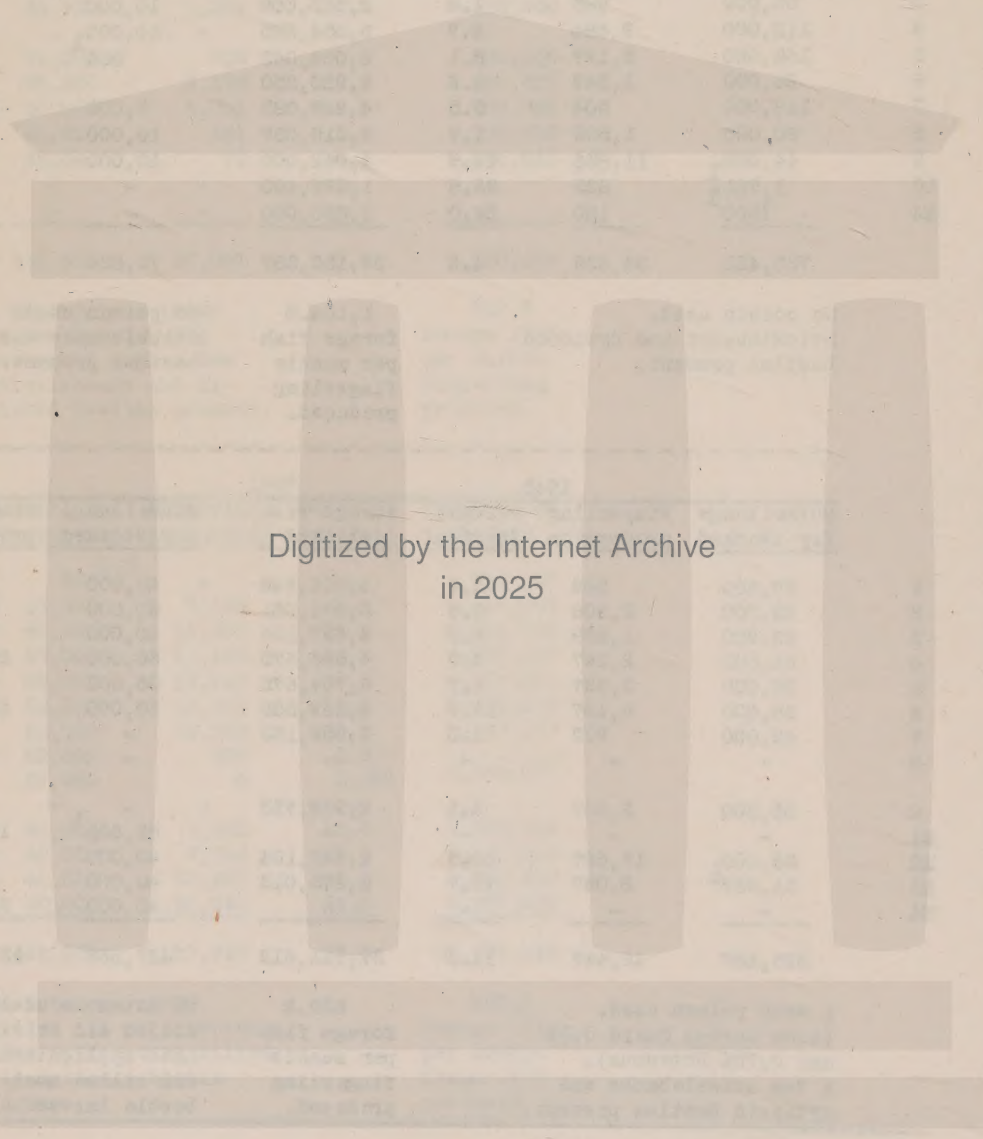

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Wisconsin has found that fertilization has been of little apparent benefit in connection with muskellunge rearing. In 1942, soy bean and cotton-seed meal applications were made on all rearing ponds at Woodruff. During the 1943 season, combinations of superphosphate and sheep manure were added to the ponds. The fertilizers worked so slowly at low water temperatures during the early part of the rearing season that muskellunge fry had completed their plankton feeding before the fertilizer had the effect of increasing the Polyphemus population. Later, in the midsummer rearing season, it was found that undesirable growths of Hydrodictyon and other filamentous algae became very abundant as a result of the combination of fertilizer and higher water temperatures. Similar trouble was experienced at the Spooner station, where heavy growths of algae enmeshed thousands of fingerlings and caused high mortalities (O'Donnell, 1945). As muskellunge fingerlings consume all swimming minnows and other fish fry within 4 to 6 days after the minnows or fry have been placed in the pond, there is little need to fertilize for plankton to feed the forage fish. However, this does not eliminate the necessity of fertilizing ponds used primarily for rearing forage fish before their transfer to the muskellunge ponds.

After ponds have been poisoned, the water levels are raised until depths of 3 to 5 feet are attained, and the water allowed to enter is only enough for evaporation and seepage for the first 3 weeks. As Polyphemus reproduce rapidly in still water, heavy cultures of this water-flea species are introduced as initial feed for the muskellunge fry. After the muskellunge have ceased feeding on plankton, the inlets are opened and approximately 30 to 35 gallons of water per minute is allowed to flow through each pond for the remainder of the rearing period. Obviously, this procedure diminishes the effect of a pond fertilization program, for nutritive material is greatly diluted and constantly flushed out with the pond effluent. It is necessary to provide running water for the ponds, as most successful muskellunge rearing ponds are less than a half acre in area and would otherwise become too warm for the species being reared (table 2).

STOCKING RATES AND CROPPING

The determination of the most efficient stocking rate per acre of pond area was a major problem in rearing muskellunge to fingerling size.

For many years, the number of muskellunge, northern pike, and walleye fry stocked in rearing ponds was effected by guesswork rather than by actual measurement. Walleye rearing ponds are still stocked in this manner to a great extent for the lack of a proper fry-counting system.

The method for segregating specific numbers of muskellunge eggs to be hatched as fry for separate ponds has been described. Although the pond jar-aquaria system can be employed satisfactorily for hatching muskellunge and northern pike pond fry, the limited supply of water furnished by one jar spigot for an aquarium is not sufficient to keep hatching walleyes in a strong swimming condition and, therefore, is not practical for that species.

In the past 6 years at the Woodruff station, varying numbers of muskellunge fry were planted in ponds experimentally. Stocking rates ranged from 14,000 to 750,000 fry per acre, and results indicated that good survival was obtained from various ponds planted with rates throughout this range (tables 1 and 2). However, some ponds planted at the rate of 130,000 to 160,000 fry per acre produced large numbers of good-size fingerlings, and these ponds were much easier to manage and keep supplied with forage than the ponds planted with more than 300,000 fry per acre. It was, therefore, found necessary to use a stocking rate commensurate with the forage available in any given rearing season. For best production, the rate of 150,000 muskellunge fry per acre with sufficient forage appears to be the proper quantity for stocking at the present time.

Sucker fry and minnows planted as forage for muskellunge fingerlings are planted at intervals throughout the rearing season. These fish are consumed so rapidly that it is not practical to compute the number required for a pond on a "per acre" basis. A more convenient method is to establish the initial plant of forage fish on the basis of "per muskie

TABLE 2.--Woodruff muskellunge fingerling production per acre

Pond No.	Acreage	1942	1943	1944	1945	1946	1947
1	0.24	1,950	-	21,479	2,120	6,779	-
2	0.08	16,550	22,612	5,287	27,575	38,475	96,287
3	0.12	8,191	8,041	27,700	15,233	64,050	99,433
4	0.40	24,210	3,357	-	5,617	73,985	27,862
5	0.25	20,708	1,744	2,944	13,588	36,524	68,588
6	0.33	4,087	-	6,660	18,748	72,175	58,830
7	0.34	1,482	3,985	3,208	2,917	-	36,900
8	0.29	5,203	1,893	1,658	-	-	NP. - 1,396)[1] Mus. - 20)
9	0.38	31,147	1,797	189	6,071	-	-
10	3.50	178	-	-	-	-	-
E1	0.07	-	-	-	-	218,214 Hybrids	93,742
E2	0.07	-	-	-	252,671	142,842	132,085
E3	0.07	-	-	-	115,528 Hybrids	121,242	292,200
E4	0.07	2,571	-	-	-	317,228	308,442
Total acreage	6.21						
Average annual prod. per acre		5,606	3,838	8,413	19,932	77,059	76,526
Number acres in production		6	1.86	2.03	2.28	1.70	1.80

[1]Experimental ponds.

stocked." The rate of about 100 hatched sucker fry per muskellunge fry stocked generally gives the best results. The amount of larger forage fish required for a muskellunge rearing pond is dependent on several factors, such as number of muskellunge, length of rearing season, size of forage fish, and size of pond (tables 1, 2, and 3). After all hatchery sucker fry have been consumed, larger forage fish are added every 3 or 4 days or less throughout the remainder of the season according to the appearance and actions of the advanced fingerlings in the ponds.

In reviewing table 1, it will be noted that the "number of forage fish per muskellunge fingerling produced" gives some indication as to the relative efficiency of various forage-stocking rates. After predators had been eliminated, the forage-stocking rate was reduced and even better production resulted.

Through experimentation in removing fingerlings at various dates, it has been discovered that the periodic removal, or cropping, of muskellunge from a pond after they reach a size of 2 inches is very desirable. It is obvious after examining table 4 that the best producing ponds were those which were cropped regularly throughout the rearing season. The removal of 2- to 6-inch fingerlings is accomplished without disturbing the pond. Rectangular box traps covered with 1/8-inch mesh hardware cloth and measuring about 4 by 2 by 3 feet in depth, a cone tunnel attached, are used for removal work. A 16-mesh window-screen lead is attached to the trap tunnel and fastened securely to the pond bank with a stake.

TABLE 3.--Rearing span for muskellunge fingerlings in Woodruff rearing ponds

Pond No.	1942			1943			1944		
	Date stocked	Date last muskellunge removed	Total days reared	Date stocked	Date last muskellunge removed	Total days reared	Date stocked	Date last muskellunge removed	Total days reared
1	May 9	July 28	81	-	-	-	May 18	July 13	57
2	May 16	July 25	71	June 1	July 16	46	May 20	July 11	52
3	May 9	July 28	81	June 1	July 16	46	May 20	July 12	53
4	May 9	July 29	82	June 1	July 23	53	-	-	-
5	May 9	August 1	84	June 24, 26	July 23	30	May 21	July 17	58
6	May 9	August 1	84	-	-	-	May 19	July 11	54
7	May 9	August 3	86	June 1	July 20	50	May 24	July 10	48
8	May 9	August 3	86	June 1	July 20	50	May 24	July 10	48
9	May 18	August 3	77	June 1	July 20	50	May 20	July 11	53
10	June 10, 11	September 8	91	-	-	-	-	-	-
E4	June 6, 8	July 6	31	-	-	-	-	-	-
			---			---			---
Average number days reared			77.6			46.4			52.8

Pond No.	1945			1946			1947		
	Date stocked	Date last muskellunge removed	Total days reared	Date stocked	Date last muskellunge removed	Total days reared	Date stocked	Date last muskellunge removed	Total days reared
1	June 5	July 20	46	May 21	July 16	57	-	-	-
2	June 3, 6	July 18	46	May 19, 20	July 12	55	June 2, 10	July 15	44
3	June 3, 6	July 19	47	May 19, 20 and 21	July 13	56	June 3, 4	August 1	60
4	May 31 and June 7, 9	July 27	58	May 23, 24 and 25	August 14	84	June 6, 7	August 22	78
5	June 2	July 27	56	May 22, 24	July 20	60	June 8	August 13	67
6	June 1	July 31	61	May 23, 24	July 25	64	June 2, 3	July 28	57
7	May 30 and June 1, 5	August 2	65	-	-	-	June 1, 2	August 4	64
8	-	-	-	-	-	-	[1] N.P. May 25	July 10	47
							[1] M. June 5	July 10	36
9	May 25 and June 4, 7	July 16	53	-	-	-	-	-	-
E1	-	-	-	May 12	July 25	75	June 7, 8	August 20	75
E2	June 6	July 30	55	May 23, 24	July 11	50	June 7, 8	July 24	48
E3	May 7	June 29	54	May 23, 25	July 10	49	June 8	July 23	46
E4	-	-	-	May 23, 25	July 11	50	June 8	July 22	45
			---			---			---
Average number days reared			54.1			60.0			58.4

[1] Experimental - not included in totals.

TABLE 4.--Woodruff muskellunge rearing-pond fingerling production by size

Pond No.	1942					1943					1944				
	1-3/4 to 2	2 to 3	3 to 4 (inches)	4 to 5	5 to 10	1-3/4 to 2	2 to 3	3 to 4 (inches)	4 to 5	5 to 10	1-3/4 to 2	2 to 3	3 to 4 (inches)	4 to 5	5 to 10
1	-	165	141	162	-	-	-	-	-	-	3,917	864	-	-	374
2	388	215	441	280	-	884	-	887	-	38	3,379	20	-	-	624
3	-	-	652	331	-	-	-	896	-	69	1,533	1,124	53	-	614
4	8,349	600	314	421	-	-	-	1,149	-	194	-	-	-	-	-
5	3,152	1,393	-	392	240	-	-	-	-	436	-	2	-	-	734
6	-	1,107	-	167	75	-	-	-	-	-	-	895	225	1,078	-
7	-	50	-	269	185	-	-	1,093	-	262	-	-	298	393	-
8	-	283	800	408	18	-	-	-	-	549	-	-	-	481	-
9	9,982	839	500	-	515	-	-	-	-	683	-	-	72	-	-
10	-	-	-	-	625	-	-	-	-	-	-	-	-	-	-
E4	-	-	180	-	-	-	-	-	-	-	-	-	-	-	-
Total	21,871	4,652	3,028	2,430	1,658	884		4,025		2,231	8,829	2,905	648	1,952	2,346
Percent fry planted	2.97	0.63	0.41	0.33	0.22	1.24		5.67		3.14	2.68	0.88	0.19	0.59	0.71

Pond No.	1945					1946					1947				
	1-3/4 to 2	2 to 3	3 to 4 (inches)	4 to 5	5 to 10	1-3/4 to 2	2 to 3	3 to 4 (inches)	4 to 5	5 to 10	1-3/4 to 2	2 to 3	3 to 4 (inches)	4 to 5	5 to 10
1	-	-	509	-	-	-	-	925	-	702	-	-	-	-	-
2	-	2,007	199	-	-	-	-	2,130	15	933	5,000	-	900	1,803	-
3	1,120	228	480	-	-	-	3,350	3,120	82	1,134	-	6,450	3,250	-	2,232
4	-	-	1,693	554	-	24,125	1,611	-	-	3,858	4,550	2,200	3,015	-	1,380
5	557	1,708	454	678	-	7,700	-	-	-	1,431	11,800	-	1,000	-	4,347
6	308	4,566	534	779	-	16,100	428	5,113	-	2,177	16,200	-	200	1,215	1,799
7	-	-	586	-	406	-	-	-	-	-	11,217	204	50	125	950
9	-	975	812	501	19	-	-	-	-	-	-	-	-	-	-
E1	-	-	-	-	-	-	9,200	3,588	-	2,587	1,400	3,750	125	-	1,287
E2	12,128	4,273	-	-	1,286	7,000	600	2,012	387	-	3,250	2,000	2,850	1,146	-
E3	-	-	8,087	-	-	4,804	200	1,100	2,383	-	13,800	5,000	-	1,661	-
E4	-	-	-	-	-	20,196	-	430	1,580	-	15,500	4,300	-	1,791	-
Total	14,113	13,757	13,354	2,512	1,711	79,925	15,389	18,418	4,447	12,822	82,717	23,904	11,390	7,741	11,995
Percent fry planted	3.56	3.47	3.37	0.63	0.43	18.68	3.59	4.30	1.03	2.99	18.1	5.2	2.5	1.7	2.6

FORAGE

The importance of proper feeding for successful muskellunge-fingerling culture cannot be overemphasized. From the experience gained during the 1942 and 1943 rearing seasons at Woodruff, it is evident that stocking forage fish at the rate of 1,000 to 2,000 per muskellunge fingerling produced was unnecessary because the surplus was apparently utilized by predators (table 1).

The first food taken by the muskellunge consists solely of Polyphemus and other cladocerans. Unlike fish-cultural stations that maintain a supply of Daphnia, Woodruff does not retain Polyphemus in year-round cultures. Silk bolting-cloth seines are used for collecting tank loads of Polyphemus from nearby lakes and flowages where it is abundant. Three or four tank-truck loads of this species are added to each pond at the beginning of the rearing period, and a good supply of plankton is then available for the muskellunge fry. As the Woodruff rearing ponds are supplied with water by a gravity feed from a natural lake, there is a certain amount of plankton entering the ponds at all times after the inlets have been opened at the end of the first 3-week period. After the young muskellunge have fed on Polyphemus for about 7 days, they have grown sufficiently to prey upon small fry of other species.

Since 1943, swimming sucker and red horse fry 2 to 3 days old have been put in the Woodruff ponds shortly before the muskellunge fry are ready to feed on them. Prior to 1943, sucker fry still in the dormant state were introduced to the ponds and high mortalities resulted. Sucker and red horse fry are hatched from artificially fertilized eggs taken during the spring spawning season. The eggs are fertilized in much the same manner as walleye eggs and require about the same amount of care. From 30,000,000 to 50,000,000 sucker fry have been produced annually at various hatcheries and transported to the Woodruff rearing ponds for muskellunge forage (table 1).

The ideal procedure for accumulating sucker fry as forage is to attempt to gather eggs at staggered dates. If this can be accomplished, there is no peak in the hatch coming off at any one station and sucker fry plants can be staggered to coincide with the various hatches of muskellunge fry.

The latest-spawning forage fish suitable for hatching and direct feeding to muskellunge is the red horse. Red horse fry are much larger than the sucker fry and are readily eaten by the small muskellunge. The only unfavorable feature of obtaining red horse eggs is that large quantities of adults cannot be located at one time or at one location so that eggs can be procured in amounts sufficient to make the operation economical. Herring and cisco eggs have also been hatched at Wisconsin muskellunge rearing stations, and the resulting fry have been placed in muskellunge rearing ponds as forage. Herring and cisco fry were included in the forage fish stocked in the Woodruff rearing ponds during the 1942 and 1943 seasons (table 1).

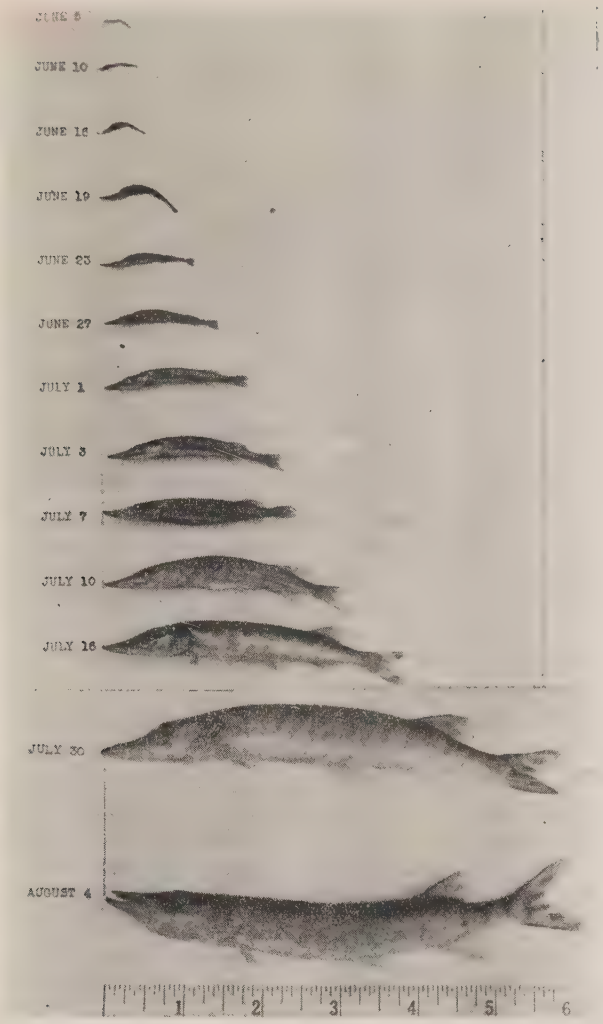
In numbers, initial hatchery sucker and red horse fry plantings made up the bulk of the forage fish fed to muskellunge fingerlings at Woodruff. It is generally true that the length of the rearing season governs the number of larger forage fish fed, more than the other factor previously mentioned (tables 1 and 3). A review of the break-down of all forage fish supplied from 1942 through 1947, in table 5, confirms this statement.

In table 5, the fish listed in the column "All other forage fish" include fingerlings and minnows from 1 to 3 inches in length, with the exception of herring and cisco fry included in the totals for

TABLE 5.--Forage fed muskellunge fingerlings in 6-year period at the Woodruff rearing station

Year	Days reared	Sucker and redhorse fry	All other forage fish
1942	77.6	20,533,789	16,616,598
1943	46.4	12,736,157	1,669,535
1944	52.8	6,280,401	*
1945	54.1	36,690,612	1,271,000
1946	60.0	49,913,343	12,744,323
1947	58.4	32.961.366	6.796.287

*No record of "other forage" kept in 1944.



(Photo courtesy of author)

FIGURE 7.--Growth rate of muskellunge fry 15 days old (June 5) to advanced fingerling 75 days old (August 4).

1942 and 1943. The species included are suckers, perch, blunt-nosed and fat-headed minnows, red-bellied dace, and lake shiners. The bulk of "other forage" consisted mainly of lake shiners, as they are abundant in waters throughout the Woodruff area and are the preferred food of the advanced muskellunge fingerling.

After the muskellunge reach a length of 2 inches, common lake shiners, fat-headed minnows, and red-bellied dace are introduced to the rearing ponds to supplement the food supply. To reach a length of 6 inches, one fingerling muskellunge consumes approximately 300 to 500 forage fish in 60 days; and in ponds producing large numbers of muskellunge, it is necessary to add from 10,000 to 20,000 shiners and other minnows at 3- or 4-day intervals.

It has been learned that to prevent bruising and subsequent fungous growths, much care has to be given the shiners while they are being seined and transported to the muskellunge ponds. It is believed that much of the muskellunge fingerling mortality not accounted for by predators was due to fungoused minnows which were eaten by the young muskellunge.

GROWTH RATE OF MUSKELLUNGE FINGERLING

All fish-culturists take particular interest in rearing fish species which they can aid in growing to a larger size in a short period of time and on an economical basis. The young muskellunge lends itself readily to this rearing category, but its growth rate is so rapid and its food consumption is so great that it poses a special problem in pond management, as previously explained in this report.

If unlimited amounts of forage fish can be supplied to muskellunge rearing ponds, then the length of time the young muskellunge is held in the pond is the only remaining factor which would restrict its growth rate (figure 7).

The growth rate of muskellunge held in rearing ponds cannot be compared equitably with that of other species found in nature, owing to the method of "force feeding" employed in muskellunge culture. However, in checking results obtained on the growth of young muskellunge, it was deemed necessary to compare them with some similar species for which data are available. An examination of Carbine's report (1942) on the life history of the northern pike (Esox lucius L.) in Houghton Lake, Michigan, hastens the conclusion that the northern pike growth rate closely parallels that of the young muskellunge.

It is quite apparent from table 6 that after they reach a length of 141 millimeters, muskellunge fingerlings reared in ponds have a decided edge in growth over the northern pike reported by Carbine.

Outstanding examples of growth are the muskellunge fingerlings retained for winter hold-overs at Woodruff during the 1947 season. At the end of 92 days of

TABLE 6.--Comparison of growth rates of northern pike (Esox lucius L.) and muskellunge (Esox masquinongy masquinongy Mitchill) fingerlings

(Northern pike data after Carbine, 1942)

Rearing days	Total length of northern pike (Peterson's Ditches, Michigan) 1939	Total length of muskellunge (Woodruff Rearing Ponds) 1947
	millimeters	millimeters
0	13.8	13.0
5	-	13.4
10	19.4	16.9
15	28.5	24.3
20	44.2	45.1
25	-	46.4
30	57.6	60.0
35	105.5	76.8
40	-	96.7
45	106.7	115.1
50	127.4	127.6
55	154.8	141.3
60	-	165.5
65	166.2	169.2
70	-	173.2
75	-	178.8
80	167.6	204.5
	(1,187 fish in samples)	(137,747 fish in samples)*

*The 1947 production at Woodruff (table 1). Total length has been converted into millimeters for easier comparison.

rearing, these muskellunge had reached an average length of 10-1/2 inches. Generally young muskellunge grow slowly for the first 25 days after hatching, as their cannibalistic feeding habits are not well developed. After 4 or 5 days of feeding on sucker fry, however, the growth rate takes a phenomenal ascent, as shown by the rate of increase of the muskellunge in figure 7 after June 16, the 26th rearing day. Another sharp upward trend in growth is made after the muskellunge begin feeding on larger minnows, and rapid growth continues until the end of the first rearing season.

The majority of muskellunge fingerlings are removed and planted from the Woodruff rearing ponds at the end of 2 months, when they have reached a length of 6 inches.

It is interesting to note that there may be a considerable variation in weight for young muskellunge of the same length. This fact was brought out in 1944, when young muskellunge (all 6 inches in length) from four different ponds were weighed (table 7).

The most reasonable explanation given for the variation in table 7 is offered

TABLE 7.--Weights of 6-inch muskellunge from Woodruff rearing ponds

Pond No.	Number of 6-inch muskellunge per pound
1	42
2	64
3	52
5	35

by the pond foreman, who states that larger minnows were placed in ponds 2 and 3 and the muskellunge were not yet large enough to cope with the minnows--although this does not explain the uniform growth in length. During the 1947 season, pond 3 at Woodruff produced 2,232 6-1/2-inch muskellunge fingerlings, which averaged 25 per pound for a total weight of 89 pounds when the pond was drained.

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The osprey, a spectacular fisherman that often takes good-sized fish, sometimes has reason to regret the protection given to the bald eagle. The fish hawk is a big bird, but the eagle is bigger, equally able to maneuver in the air, and he occasionally highjacks the osprey of a choice fish. When the osprey lets go its prize, the eagle shoots after the falling fish, sometimes seizing it in mid-air. The osprey may then resume fishing or go hungry.

FISH CULTURE IN MOROCCO

(Photo courtesy of the author)

J. G. Prud'homme
Fishing-Club of Fez
10 Rue Decanis
Fez, Morocco

NATIVE FISH life in Morocco in 1934 seemed to be in transition between European and African life, the latter being represented by some 15 species of barbel widely differentiated according to location. There may be noted the complete absence of catfish and the presence of unimportant species of blenny, loach, and atherin.

In the mountains and above a height of 1,000 meters (about 3,300 feet) was found the most interesting natural stocking, abundantly represented at that time

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Mr. Prud'homme is technical adviser of the Fishery Federation of Morocco.

Translation by Miss Barbara Ethier, Office of Foreign Activities, Fish and Wildlife Service.

by the macrostygma variety of brown trout, including, in addition to the normal type with red and black spots, a type with black spots only, and several lacustrine types without any coloring. It is to be noted also that altitude does not have, in this country, the absolute value that it has in Europe for the distribution of species, and that for one altitude, by reason of the summer heat, the waters offer widely varying possibilities, depending upon whether they are deep waters (fed by thaws) or surface waters.

The problem was to stock with imported species several mountain lakes too warm for trout, two large flood dams, and a large inshore lagoon. In the latter areas the depth or the proximity of the sea lessened the summer heat.

Among the species selected, in the first place, were the cyprinoids. Carp already existed in two lakes, as this species had been introduced earlier by the Waters and Forests Department of the Protectorate. Rudd and tench fry were easily brought in by boat or by plane. Two small lakes were stocked with the fry, and these spawned the next year.

The same was true of largemouth black bass, in spite of great losses. The fry were put into these two lakes, and spawning took place the following year.

We were thus assured of on-the-spot breeding, which resulted in other equally productive restockings. The project was carried out with these three species.

The introduction of rainbow trout was handled by making several shipments of eggs, some by boat and others by plane. The latter mode of transportation gave by far the best results.

The shipping of pike and perch was solved in an original way, thanks to the help of Inspector General Vouga of Neuchatel (Switzerland). For pike, particularly, the importation of fry was extremely complicated. First, it was difficult to get the fry; then, it was necessary to put them on board at Bordeaux the day the ship left; after that, the importation involved 2 days of shipment, then clearance, and, again, shipment lasting from 20 to 24 hours from Casablanca to our lakes. These fry arrived at a cost not far from the value of their weight in gold. Altogether, 22 live fry arrived by boat. Once, expecting to receive by boat 24 20-inch fry, I was able to claim only dead fish. In two trips, I myself imported 21 fish by auto, by way of Spain, in a well-insulated container with a very large ice compartment which took up the entire space of the baggage carrier.

Weary of these ridiculous results, out of proportion to the expense and the loss of time, I sought information from various Frenchmen, then from Mr. Vouga, about the possibility of shipping pike eggs. In France, shipment was considered impossible at that time because, as will be seen, of erroneous interpretations of unsuccessful results. Inspector General Vouga, who possessed a thorough technical knowledge of pike as well as of other fish, believed shipment in a few hours possible, as he had done it often in his own canton. As for the success of a shipment lasting at least 50 hours, only experience could show what would result.

The experiment was made by shipping by plane from Neuchatel to Fez a laboratory tank containing 5,000 rainbow trout eggs and 50,000 pike eggs. Some of these eggs were shipped in moist condition, in thermos bottles, with air, without air, and with oxygen; others were shipped in canvas boxes like those containing trout eggs. The ages of these eggs, carefully noted on each lot, ranged from 2 to 10 days. The quantity of ice was the same as that used for the trout.

When the case was opened after a total shipping time of 50 hours, only the eggs 8 days old at the time of departure were still alive. The 9- and 10-day-old eggs had hatched on the way. The younger eggs and all the eggs in the thermos bottles were dead.

The 8-day-old eggs, put to hatch on a brass-wire frame at 15° C. (59° F.), hatched freely, as did the rainbow trout eggs. This occurred in April 1939. The mystery had been solved, and at the same time there was evidence of the reason for the failure of previous shipments of pike eggs. These eggs proved capable of shipment in embryo--but not before--and within the theoretical time limit conditioned by the surrounding temperature and the number of degree-days proper to each species. It is this short lapse of time which makes the operation delicate, although in theory nothing would hinder increasing the time by 24 hours,

for example, by using a better-insulated container and a larger quantity of ice. The preliminary thermic calibration of such a tank should be done very accurately in a laboratory.

After this shipment, a second of 50,000 8-day-old eggs, for the Waters and Forests Department of the Protectorate, gave a 95-percent hatch at the official station. By the first of June, 10,000 eggs of a late spawning had not yet come through.

Next, the problem of perch was tackled and solved in the same way. Mr. Vouga consented to gather in the lake at Neuchatel about 50 bands of eggs, their ages undetermined but varied. These eggs were shipped only in a moist, chilled atmosphere on frames of cloth in the customary manner; and the bands were immersed immediately ... Three months later, the first catches of perch were reported. They are in the millions now. It seemed certain that, the number of degree-days for perch being practically equal to that for pike, the eggs which hatched must have been approximately the same age as the pike eggs of the earlier experiments.

From these experiments we have developed a general principle for the shipment of fish eggs. Where it is a matter of large separate eggs of the salmon, eggs temporarily adhesive, like those of pike, or small eggs in bands like those of the percoids, shipment is possible during the period between embryo and hatching, which is evidently conditioned by the number of degree-days of the species and the surrounding temperature. Shipment should be made dry. The failure of the thermos bottles was undoubtedly due to the undesirable bacterial growths resulting from the unchanged water. The shipment of some eggs in water did not seem technically impossible. A method of this kind, however, would require the shipment of an enormous weight of water and would not, for this reason, have any practical interest.

The earlier attempts in France at shipment of pike eggs, dry or in water, were unsuccessful, probably because in the former condition the eggs were not embryonic and in the latter condition the water was unchanged or insufficient.

It will be noted that the optimum age of 8 days, given above for my experiments, is entirely relative and is of value only for the initial temperature of the water at the incubation laboratory at Neuchatel. It could be 7 days or 9 days with the start of incubation in warmer or colder water. More precisely, the optimum date for the dispatch of pike eggs is when the number of days of incubation times the temperature (Centigrade) of the water equals 75.

To resume, the results of acclimatizations have been satisfactory and the speed of increase in certain unstocked lakes has been analogous to that observed earlier in fish culture in Australia and New Zealand.

In several lakes containing much plankton and bottom life, rainbow trout usually grew to 4 to 6 pounds when 3 years old, then disappeared suddenly, probably because of fatty degeneration of the liver. The later introduction of cyprinoids (by well-meaning persons) "to give the trout something to eat," ended in such an enormous multiplication of fry that to maintain a normal ratio required, in some cases, the introduction of pike, perch, or black bass. Where it has been possible to maintain the rainbow trout, its maximum weight is 1 kilogram (2.2 pounds).

In running water the rainbow trout permits a good additional return in brown trout, not exceeding 1/2 pound, a weight attained in 1 or 2 years. It furnishes a great profit to the fishery, especially at the beginning of the project. Natural reproduction has not been observed for either trout, although on the coastal gravel and spawning grounds in spring we may find females full of first-rate eggs, ready to spawn.

In the lakes there are excellent returns from the perch and black bass--especially from the black bass, which finds here the climate of its native habitat. The black bass profits enormously from the exogenous food and does not display the propensity (sometimes shown by perch) toward excessive multiplication with a tendency to dwarfism. Recorded weights are about 6 pounds for black bass and about 4 for perch.

Pike, whatever their origin may be, have shown phenomenal rapidity of growth. Among those hatched in 1939, females exceeded 20 pounds in weight, and hundreds of these fish are caught every year. Reproduction is very good in certain lakes

but lacking in some others although they offer good conditions.

We may note the benefit of egg-importation methods which have allowed these fishes to get rid of their particular parasites and have proved the value of modern fish-cultural practices.

For all species there has been observed a very definite advance in sexual maturity in evident relation to the climate.

Our effort has had an effect in 1948 upon the acclimatization of brook trout (Salvelinus fontinalis) for mountain lakes and streams.

And now a few words about the general purposes of these experiments. As the waters of Morocco are so small in extent, but potentially rich, everything has been done to develop game fishing to the exclusion of commercial fishing.

There have been some errors in management at the beginning, because we had adopted for our fish culture the concepts of old Europe before realizing that they were only routines without real scientific foundation. Most great nations developed their possibilities so badly that they are, and for a long time will be, dependent upon small, well-organized countries like Switzerland and Denmark for the production of trout eggs. Furthermore, the science of the management of the waters is only in its beginning. The return from artificial restocking is usually poor because very often these operations consist of dropping fry into the water and letting them shift for themselves as they can--if they can. However, it is not zoologists, nor biologists, nor chemists that we lack, but administrators able to coordinate and synthesize the various activities which combine to maintain or improve the productivity of the waters. American and Canadian readers will be surprised to learn that in most European countries (Switzerland excepted) fishing has remained, quite illogically, a branch of forest administration. There is no equivalent of the Bureau of Fisheries nor of the Ministry of Fisheries.

So with a little logic and the advice of our friend Inspector General Vouga, we have set down some fundamental rules concerning breeding and culture. We group fish in three classes, always with the thought of game fishing uppermost in mind:

First group. This group includes game fish of superior quality: brown trout, rainbow trout, char, and related fish. We must not permit any competition with these species, not even from the would-be "forage fishes," which divert an important part of the natural food and destroy trout eggs. Six-pound brown and rainbow trout have been produced in Morocco solely by means of a diet rich in insect larvae and gammarids. In Switzerland (Totensee) Cristivomer reach 4 pounds on this same natural provender, whereas to some extent everywhere in Europe trout rivers have been ruined by the increase of minnows and other fish of the cyprinoid family.

Second group. This includes pike (Esox lucius) and black bass, excellent game fish of rapid growth and moderate rate of reproduction, and which may be cultivated in waters where it has been proved that trout cannot live. It is necessary to have forage fishes for these species, although black bass can get along without them if the animal life is plentiful. But, as forage fishes, all species are not suitable. Carp and tench are not at all satisfactory because they grow rapidly and for this reason are not useful to more important fish for more than a few weeks, after which the carp and tench form very large schools that are valueless even to fishermen. No more satisfactory are spiny fish (perch or the small centrarchids), as they are likely to destroy pike eggs or fry. In Natal the proliferation of sunfishes, along with that of carp and tench, has almost ruined the return in black bass. The best forage fishes are cyprinoids of small size (the gudgeons), consumable at all stages of their existence by pike or black bass.

Third group. This group includes the very large number of mediocre or harmful fish: carp, tench, and small carnivorous species like sunfish, catfish, and perch. The fishes of this group are at the source of all the fish-cultural disasters of the entire world. Whenever they are introduced into foreign countries, the prodigious capacity of these species to reproduce has allowed them to supplant local (often superior) species. In Morocco, one of our mountain trout lakes has been completely ruined by carp ... In another lake the European perch has had the same effect. In a third lake, where artificial

stocking with pike was suspended during the war, the European perch has succeeded in multiplying while remaining small, and has obliged us to restock the lake not with pike fry but with 20-centimeter (8-inch) pickerel.

Shipment of fish of this group from country to country or within the interior of a country ought to be prohibited. Even as forage fishes their importation is not justified, for there are always, in any country, small native fishes whose habits are known and which can be utilized for this purpose.

The rule in fish breeding, then, is to import only fishes of superior quality and to refrain in all other cases.

These considerations will be evident to many administrators in the United States and Canada, so evident that they will not consider it wise to send information to foreigners who ask for data about breeding a particular North American fish if, left to themselves, they will make the same errors.

It is understood that "there is no universal pondfish," but there is a principle which is universal for breeding new species in all countries. What I have told you here, I wish someone had told me 15 years ago. Perhaps I shall be rendering others a service by telling them about it today.

The backpack cans and truck tanks used in fighting forest fires usually contain only ordinary water. Research undertaken to make "wetter water" is based upon the addition of small amounts of detergent chemicals to reduce the drop-forming surface tension of the water. Water so treated will adhere to and penetrate the fuels instead of running away as drops.

In 1873, the U. S. Fish Commission received 19 applications for fish. Four years later, the Commission received the great total of 254 applications. During the fiscal year 1948, the U. S. Fish and Wildlife Service received 51,959 applications for fish for stocking inland waters of this country.

The modern theory of management holds that a fishery resource cannot ordinarily be exhausted with hook-and-line fishing because the fish will bite only when there is a population greater than the food-supplying capacity of the water.

THE DIFFUSION OF OXYGEN IN FISH TANKS

For many years New York State has used oxolite stones, about 1-1/4 inches in diameter, as a means of diffusing oxygen in fish tanks. The manufacture of these liberators has been discontinued. Various types of substitutes have been tried, but none of these has proved satisfactory.

O. R. Kingsbury, Supervisor of Fish Distribution, New York State Conservation Department, Albany, New York, reports that Mr. Charles Affolter, employed at the Rome State Fish Hatchery, Rome, New York, has recently perfected an ingenious device for the liberation of oxygen in fish transportation tanks. A length of 1/4-inch rubber tubing with a 3/32-inch side wall is formed into a loop by using a T-connection of copper tubing. The size of the fish tank in which the oxygen is to be diffused, governs the length of the loop. The rubber tubing is punctured at 2- or 3-inch intervals with a small needle. The type of the tubing largely determines the size of the needle: spongy rubber takes somewhat more pressure to force the gas through the punctures.

This simple, easily constructed device is extremely efficient. Where formerly two hoke needle valves were necessary on each tank compartment, only one is used now. The oxygen is finely diffused and liberated uniformly in all parts of the tank.

WOMAN

A chemist's description of the creature known as woman:

Symbol-- Woman.

Accepted Atomic Weight-- 119.

Physical Properties-- Boils at nothing and freezes at any minute. Melts when properly treated. Very bitter if not well used.

Occurrence-- Found wherever man exists.

Chemical Properties-- Possesses great affinity for gold, silver, platinum and precious stones. Violent reactions if left alone. Able to absorb great amount of food matter. Turns green when placed beside a better-looking specimen.

Uses-- Highly ornamental, useful as a tonic in acceleration of low spirits and an equalizer of the distribution of wealth. Is probably the most effective income-reducing agent known.

CAUTION-- Highly explosive in experienced hands.

--Gorton-Pew's THE MAN AT THE WHEEL
August 1948.

PROGRESS REPORT: IMPROVEMENT OF FISH-CULTURAL PRACTICES IN OKLAHOMA

A. D. Aldrich
Oklahoma Game and Fish Department
Oklahoma City, Oklahoma

IN AN EFFORT to demonstrate the most effective methods of operation and management of fish-hatchery ponds and small lakes for the production of quality fishes, a series of demonstrations was conducted at the Holdenville hatchery during the summer of 1947.

The studies are not complete by any means. Similar demonstrations are being conducted at all the fish hatcheries so that effective fish-management practices can be designed for each of the various ecological regions of the State. The quest for more knowledge concerning the management of fishing waters should never cease. Plans and practices must frequently be altered to keep pace with the constantly changing environmental conditions and increase of angling pressure.

The management practices developed at fish hatcheries must be projected on the manageable fishing waters of the State. The results of the demonstrations described herein are intended for that purpose. It should be realized that restocking has its place in the management picture, and that restocking is but one phase of the balanced program. Planting fish will never correct the ills of habitat deficiencies or of unharvested populations of competitive nongame fishes. Every effort should be made to produce fish of the highest quality and to make the most effective use of hatchery facilities.

This project was an attempt to demonstrate various methods of pond operation and treatment for the production of desirable fish for stocking purposes, also to provide specific information which might be applicable to other waters and easily understood by pond owners.

Eight ponds at the Holdenville fish hatchery were selected for treatment and control as indicated in table 1. Ponds No. 1 and 2 are very similar in size, volume, and soil type, thus providing a control for the experiments. Ponds No. 27 and 28 are likewise similar ponds, and they were selected for the same control purpose. Ponds No. 6, 7, 8, and 25 were selected because of their variation in size and character. All ponds were measured for surface area and volume, expressed as surface acres and acre feet (table 1). All the ponds receive their water from Lake Holdenville, which lies adjacent to the hatchery and furnishes water for the City of Holdenville.

The experimental ponds were stocked with various combinations of fishes, as shown in table 2. Plankton and turbidity samples were collected and measured by standard methods at regular intervals during the course of the experiments. In table 3, turbidity is indicated as parts per million and plankton volumetrically as cubic centimeters per cubic foot of water.

The studies indicate that by fertilization the turbid waters of small lakes up to 10 feet in depth can be economically cleared and made highly productive of plankton organisms. The increase in the numbers of animal organisms per liter of water in the fertilized ponds was several times that of the unfertilized control waters (see table 4).

TABLE 1.--Fertilization schedule for Holdenville ponds

Pond No.	Surface acres	Acre feet	Fertilizer applied per acre foot at 10-day intervals: Colloidal phosphate	Cottonseed meal	Soybean meal	Pounds each applied	Total pounds fertilizer
1	2.50	14.10	No treatment				
2*	2.30	14.00	100*	50*	50*	309	3,248
6	0.43	1.2	50	25	-	76	909
7	0.48	0.97	100	-	50	145	1,406
8	0.95	2.73	100	-	-	273	2,184
25	2.38	7.68	50	-	25	-	2,170
27	0.41	0.79	No treatment				
28	0.38	0.80	100	25	-	100	1,040

*Figures for Pond No. 2 are per surface acre.

TABLE 2.--Stocking record of Holdenville experiment

Pond No.	Date stocked	Number stocked	Species stocked
1	3/26/47	20	White crappie, adult
	6/6/47	5,000	Channel catfish, fry
2	3/26/47	20	White crappie, adult
	6/6/47	5,000	Channel catfish, fry
6	3/27/47	12	Bluegill, adult
		150	Golden shiner
7	5/8/47	2,500	Bass, 1/2-inch fry
		150	Golden shiner
8	5/8/47	5,000	Bass, 1/2-inch fry
		150	Golden shiner
25	3/25/47	30	Bass, fry
	3/26/47	12	Crappie, adult
	3/27/47	20	Bluegill, adult
27	6/6/47	5,000	Channel catfish, 72 hrs. old
28	6/6/47	5,000	Channel catfish, 72 hrs. old

The production of both plant and animal organisms was highest in waters which had a turbidity of 30 to 40 parts per million and provided sufficient color to shade out and inhibit growth of undesirable rooted aquatics. Pond No. 25 remained clear all summer, owing to a continuous circulation of water; and aquatic plants (largely coontail) covered the entire pond, resulting in low production of plankton, as shown in table 3.

Examination of the water samples taken from Lake Holdenville reveals that very few plankton forms exist in deep waters where the turbidity averages as much as 92 parts per million.

Turbidity due to suspended silt was

TABLE 3.--Plankton production and turbidity

Pond No.	Plankton (averages for 10 samples) (cc per cu. ft.)	Turbidity (Jackson method) (p.p.m.)
Source	0.29	92
1	1.54	82
2	1.29	33
6	1.62	24
7	1.79	37
8	1.82	30
25	1.20	23
27	1.10	30
28	1.42	23

TABLE 4.--Plankton analysis of Holdenville hatchery ponds, 1947

Plankton	Pond No. 1	2	6	7	8	25	27	28	Lake
	(average number of organisms per liter--11 samples)								
Copepods	306	236	536	625	681	334	246	939	13
Cladocera	52	86	104	259	243	138	64	171	1
Rotifers	913	2,253	2,445	664	1,514	869	281	2,147	12
Green algae	97	100	118	84	144	131	98	40	36
Blue-green algae	2,637	6,183	4,494	2,781	3,848	6,162	56	1,071	6
Protozoa	172	1,500	1,293	307	1,753	84	4	18	8
Crustacea eggs	52	39	193	434	477	166	23	194	1
Diatoms	125	16	53	32	8	17	4	105	7
Average total of all plankters	545	1,301	1,154	648	1,086	987	97	585	10

reduced from 82 to 33 parts per million by the application of commercial and organic fertilizers at the rate of 100 pounds of each per surface acre at 2-week intervals (Ponds No. 1 and 2, table 3).

All final production data (table 5) were compiled on the day the ponds were drained.

The increase of fish production, expressed in pounds per surface acre, was very pronounced in the treated ponds. Production in Pond No. 2 was approximately double that of No. 1, which was held as the control, even though the ponds were stocked alike. The increased production of No. 2 was in direct proportion to the increase of organisms per liter of water. The size of the individual fish in these ponds was quite similar: the difference in production appeared in the greater numbers of fish in Pond No. 2.

The greatest difference in production was between Ponds No. 27 and 28. Pond No. 28 produced 18 times the weight of fish per acre of Pond No. 27 (table 5). Pond No. 28 cleared soon after fertilization and remained clear all summer. The total number of plankton organisms per liter of water in Pond No. 28 was six times greater than in Pond No. 27. The fish from Pond No. 28 were much larger, averaging 12 per pound, while those from Pond No. 27 numbered 416 per pound (table 5).

The difference in size of the individual fish and the pounds per acre from Ponds No. 27 and 28 was not proportionate to the plankton produced. The greater production from Pond No. 28 appears to be due to reduced turbidity combined with increased plankton production. Study of the relationship between turbidity and fish production indicates that high turbidity is a greater limiting factor of good fish production than reduced plankton. The size of the individual fish produced was greater in ponds of medium turbidity.

The studies demonstrated that fish of excellent quality and nearly legal size can be produced in small ponds in one summer by systematic treatment. The highest yield, 421 pounds per acre, was obtained in Pond No. 6, which was stocked with bluegills and golden shiners. The next highest production, 280 pounds per acre, resulted from a combination of bass and golden shiners; the bass in this pond were nearly all of legal length. Channel catfish, 220 pounds per acre, were next in production, averaging 12 fish per pound and of nearly legal length.

Black bass, bluegills, and golden shiners in combination yielded high production and a large percentage of legal-length bass. A combination of bass, crappie, and bluegills gave fair production per acre, but the bass were small, averaging 100 per pound.

The studies indicate that pondfishes do not make satisfactory growth in ponds where the turbidity due to suspended silt is higher than 30 to 35 parts per million.

TABLE 5.--Fish production record at Holdenville

Species	Pond No. 1	2	6	7	8	25	27	28
Bass								
Pounds of fish produced	-	-	-	58	35.50	119.48	-	-
Number of fish per pound	-	-	-	9.5	4.25	100	-	-
Channel catfish								
Pounds of fish produced	45	74.25	-	-	-	-	5.80	86
Number of fish per pound	45	40	-	-	-	-	416	12
Crappie								
Pounds of fish produced	48.75	110.5	-	-	-	80.55	-	-
Number of fish per pound	226	260	-	-	-	60	-	-
Bluegill								
Pounds of fish produced	-	-	95.62	-	71.25	131.55	-	-
Number of fish per pound	-	-	36	-	35	36	-	-
Golden shiners								
Pounds of fish produced	-	-	86.50	77.50	58	-	-	-
Number of fish per pound	-	-	30	30	30	-	-	-
TOTAL pounds of fish produced	93.75	184.75	182.12	135.5	164.75	331.58	5.8	86
TOTAL pounds per acre of fish produced	37.50	90.90	421	280	173	138.9	12	220
DATE pond was drained	11/25/47	11/26/47	11/13/47	11/14/47	11/12/47	11/7/47	11/4/47	11/5/47

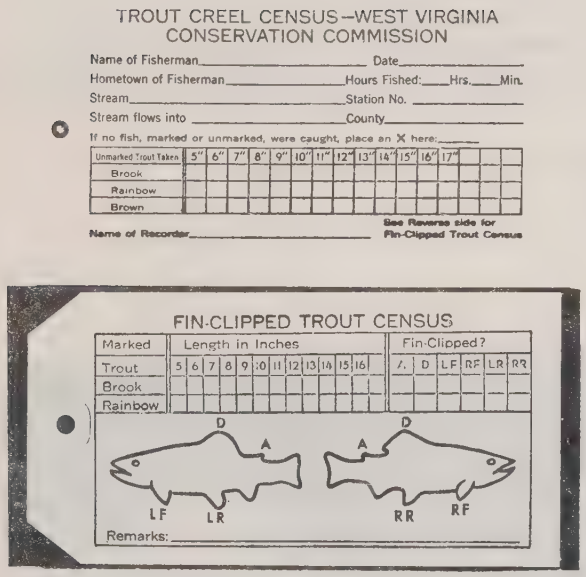
Stunting occurs in such turbid ponds even though the plankton may be abundant: this indicates that turbidity interferes with the feeding of the fish.

The use of golden shiners as forage fish in combination with bass and bluegill produces high yields and rapid growth of fish in fertilized ponds. Other minnows may be equally effective as forage for pondfishes. A 1/2-acre pond (separate report) at Holdenville produced 782 pounds of fat-headed minnows during the summer of 1947.

Satisfactory numbers of legal-length black bass and channel catfish can be produced in 6 months by systematic fertilization of the ponds and the use of forage minnows. In order to produce black bass of legal length in one growing season, the ponds should be stocked with advanced fry at a rate not to exceed 2,500 per surface acre of water.

Almost 15 million brook trout eggs are produced each year at the U. S. Fish-Cultural Station at Berlin, New Hampshire.

CREEL CENSUS TAGS



TROUT CREEL CENSUS—WEST VIRGINIA CONSERVATION COMMISSION

Name of Fisherman_____ Date_____

Hometown of Fisherman_____Hours Fished:____Hrs.____Min.

Stream_____Station No. _____

Stream flows into _____County_____

If no fish, marked or unmarked, were caught, place an X here:_____

Unmarked Trout Taken	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"	15"	16"	17"			
Brook																
Rainbow																
Brown																

Name of Recorder_____ See Reverse side for Fin-Clipped Trout Census

FIN-CLIPPED TROUT CENSUS

Marked Trout	Length in Inches											Fin-Clipped?					
	5	6	7	8	9	10	11	12	13	14	15	16	A	D	LF	RF	LR	RR
Brook																		
Rainbow																		

D A A D

LF LR RR RF

Remarks:_____

Shipping tags have been prepared by the Division of Fish Management, West Virginia Conservation Commission, for use in the creel census on experimental trout streams in that State. Unlike cards or census pads, these tags may be put on a metal ring or a string and hung on a fieldworker's belt. Stiff enough to write on, the white tags are stamped with indelible ink (not printed) and have stood the test of rainy weather. The system of recording data on fin-clipped trout has proved very satisfactory.

The tag was designed by E. A. Seaman, Chief, Division of Fish Management, and P. E. Swasey, assistant fishery biologist, of the West Virginia Conservation Commission. Helpful suggestions were received from Dr. D. S. Shetter of the University of Michigan.

FARM PONDS AND FISH DEVELOPMENT

Failure in fish development in farm ponds in the Midwest is due primarily to improper adjustment of the size of the farm pond to the adjacent watershed, excessive weed growth, and lack of care in stocking, is the belief of W. L. Anderson, SCS, Milwaukee, Wis. Proper adjustment of the size of the pond to that of the watershed supplying water for it is essential for most efficient water supply. Controlling weeds in the pond and proper stocking with fish are other essential requirements for successful pond management.

--Soil Conservation 13 (12): 272.

SURVEY OF FISH CULTURE IN THE UNITED STATES

A. V. Tunison, S. M. Mullin, and O. Lloyd Meehean
U. S. Fish and Wildlife Service
Washington, D. C.

FISH CULTURE has been in existence as a hobby or profession since 2100 B.C. (Slack, 1872). Fish culture spread from China (considered its birthplace) to the Roman Empire, Central Europe, England, and America.

Although historians have not agreed as to who should receive credit for establishing the first bona fide fish hatchery in the United States, there is reason to believe that the honor should go to Seth Green, who established his hatchery at Mumford, New York, in 1864. At that time, and for at least the next 50 years, the primary concern of the fish-culturist was to introduce new species into waters unproductive of desirable fish. Hatcheries were required for that purpose, and various States and the Federal Government embarked upon a modest construction program.

In 1900 the Federal Government was operating 34 hatcheries and egg-collecting stations. The number of State hatcheries in operation at that time has not been determined, but it is quite likely that the States were maintaining as many as the Federal Government. Although of modest extent, fish culture was established as a business in the United States. Like other professions, fish culture was beset with problems, policies, and fancies. Discussions of these difficulties provide interesting reading in some of the early volumes of Transactions of the American Fisheries Society.

In the 1920's and 1930's, a few biologists questioned the use made of some of the hatchery product. These men stimulated thought on the value of hatcheries and drew attention to the need for knowledge of what happened to hatchery fish after they were liberated, as well as to the need for knowledge of the social and economic life of the native residents of streams and lakes. With the publication and discussion of such ideas, opinion with regard to the significance of fish culture began to change. Although during the last decade the number of hatcheries and the number of fish-culturists have increased, and payrolls and operating expenses have grown, most fishery workers--administrators, fish-culturists, or biologists--have come to realize that the fish hatchery, once an end in itself, can now be more usefully employed as an important tool of fishery management.

The extent of fish culture as a nation-wide business was shown for the first time by Swepson Earle in an article entitled "Fish Culture Is Big Business in the United States," which appeared in the PROGRESSIVE FISH-CULTURIST in July 1937. Frequent use of this information, despite the elapse of 11 years since its compilation, prompted the authors to undertake another survey of fish culture as it exists today. The data presented in the accompanying tables were secured from questionnaires sent to the States and from the records available to the U. S. Fish and Wildlife Service.

In 1937, 46 States reported the operation of 383 hatcheries and the Federal Government operated 87 units in 37 States. At the present time, these States operate a total of 522 units (table 1) and the Federal Government, 99 in 43 States. The increase in units operated amounts to 32 percent. A number of factors accounted for this increase. At the time of the

TABLE 1.--State and Federal hatcheries

Federal hatchery - Address	State hatchery - Address
	Alabama
Carbon Hill - Carbon Hill	Alabama State Fish - Estaboga
Elk River - RFD 2, Elkmont	Lone Park - Birmingham
Marion - Marion	Mobile - Springhill
	Arizona
McNary - McNary	Hunt Bass - Phoenix
	Page Springs Rearing Ponds - Cornville
	Pinetop - Pinetop
	Tonto Trout - Payson
	Arkansas
Corning - Corning	Centerton - Centerton
Mammoth Spring - Mammoth Spring	Lake Hamilton Fish - Hot Springs
	Lonoke - Lonoke
	California
Coleman - Rt. 1, Box 829, Anderson	Basin Creek - Tuolumne
	Brookdale - Brookdale
	Burney - Burney
	Central Valleys - Box 186, Elk Grove
	Crystal Lake - Burney
	Fall Creek - Copco
	Feather River - Clio
	Fillmore - Fillmore
	Hot Creek - Bishop
	Huntington Lake - Lakeshore
	Kaweah - Three Rivers
	Kern - Kernville
	Kings River - Fresno
	Lake Almanor - Box 1116, Westwood
	Madera - c/o The Falls, Bass Lake
	Mohave River - Victorville
	Mt. Shasta - Mt. Shasta City
	Mt. Tallac - Nr. Camp Richardson
	Mt. Whitney - Independence
	Prairie Creek - Orick
	Sequoia - Nr. Visalia
	Tahoe - Tahoa City
	Whittier - Whittier
	Yosemite - Yosemite National Park
	Yuba River - Camptonville
	Colorado
Creede - Creede	Buena Vista - Buena Vista
Leadville - Leadville	Cedaredge - Cedaredge
	Denver - Henderson
	Durango - Durango
	Estes Park - Estes Park

(Continued)

TABLE 1. (Continued)

Federal hatchery - Address	State hatchery - Address
	Colorado (continued)
	Fort Collins - Bennevue
	Glenwood Springs - Glenwood Springs
	La Jara - La Jara
	Monument Lake - Weston
	Pitkin - Pitkin
	Rye - Rye
	Walden - Walden
	Wray - Wray

	Spawning stations
	Parvin Lake - Log Cabin
	Tarryall Lake - Jefferson

	Retaining ponds
	Bellaire - Buford
	Colt Retaining Ponds - Lyons
	Coal Dale Ponds - Coal Dale
	Crystal River - Carbondale
	Hershman Ponds - Drake
	Rio Grande - Monte Vista
	Rocky Mt. Trout Farm Consolidated Denver - Henderson
	Connecticut
	Burlington (Trout) - RFD, Unionville
	Kensington (Trout) - Kensington
	Noank (Lobsters, flatfish) - Noank
	Voluntown (Trout) - Voluntown
	Windsor Locks (Trout) - Windsor Locks
	Florida
Welaka - Welaka	Blackwater River - Holt
	Wewahitchka - Wewahitchka
	Winter Haven - Eagle Lake
	Georgia
Chattahooche Forest - Margret	Bowens Mill - Fitzgerald
Cohutta - Cohutta	Richmond Hill - Richmond Hill
Lake Park - Lake Park	Summerville - Summerville
Warm Springs - Warm Springs	Deer Creek Fish - Cuthbert
	Walton County Fish - Social Circle
	Idaho
Hagerman - Hagerman	American Falls - American Falls
Salmon - Hagerman	Ashton - Ashton
Warm River - Ashton	Boyd Creek - Kooskia
	Clark Fork - Clark Fork
	Coeur d'Alene - Coeur d'Alene
	Crystal Creek - Fernwood

(Continued)

TABLE 1. (Continued)

Federal hatchery - Address	State hatchery - Address
	Idaho (continued)
	Eagle - Eagle
	Grangeville - Grangeville
	Hagerman - Hagerman
	Hay Spur - Gannett
	Henrys Lake - Lake
	McCall - McCall
	Mackay - Mackay
	Sandpoint - Sandpoint
	Twin Falls - Twin Falls
	Whiskey Creek - Grace
	Illinois
	Carlyle - Carlyle
	Geneseo - Geneseo
	Mattoon - Mattoon
	Rockford - RD 1, Pecatonica
	Spring Grove Hatchery and Egg-taking Station - Spring Creek
	Wyanet (operated from Geneseo) - Wyanet
	Yorkville - Yorkville
	Indiana
Argos - Rochester	Avoca - Avoca
Rochester - Rochester	Bass Lake - Bass Lake
	Driftwood - Vallonia
	Fawn River - Orland
	Ferdinand - Ferdinand State Forest
	Lincoln - Lincoln State Park
	Maxinkuchee - Culver
	Riverside - Indianapolis
	Scales Lake - Scales Lake State Forest
	Shakamak - Shakamak State Park
	Tri-Lakes - Tri-Lakes
	Wawasee - Lake Wawasee
	Yellowwood - Yellowwood State Forest
	Iowa
Fairport - Muscatine	Bedford - Bedford
Guttenberg - Guttenberg	Beed Lake - Hampton
Manchester - Manchester	Clear Lake Pond - Clear Lake
	Cresco Pond - Cresco
	Diamond Lake Pond - Spirit Lake
	Dolliver Park Pond - Fort Dodge
	Eagle Grove Pond - Eagle Grove
	Hottes Lake Nursery - Spirit Lake
	Humboldt - Humboldt
	Henry Kramer Trout Ponds - Elkader
	Lake Keomah - Oskaloosa

(Continued)

TABLE 1. (Continued)

Federal hatchery - Address	State hatchery - Address
	Iowa (continued)
	Lake Park Nursery - Lake Park
	Lake View - Lake View
	Lake Wapello - Drakesville
	Lanesboro Pond - Lanesboro
	Mechanicsville Pond - Mechanicsville
	Pleasant Lake Nursery - Spirit Lake
	Prairie Lake Nursery - Spirit Lake
	Sievert Springs - Decorah
	Storm Lake Pond - Storm Lake
	Strawberry Point Ponds - Strawberry Point
	Twin Springs - Decorah
	Welch Lake Nursery - Spirit Lake
	---
	1 pike perch hatchery - Spirit Lake
	1 pike perch hatchery - Clear Lake
	1 trout hatchery - Strawberry Point
	1 trout hatchery - Decorah
	1 base Mississippi rescue station - Lansing
	1 base Mississippi rescue station - Sabula
	Kansas
Farlington - Farlington	State Fish - Pratt
	Kentucky
Louisville - Louisville	Gatliff State Fish - Woffard
	Trigg State Fish - Glasgo

	Bass rearing stations
	Harlan Fish Ponds - Smith
	Pike County Fish Ponds - Praise
	Somerset Ponds - Somerset
	Ashland Ponds - Ashland
	Louisiana
Natchitoches - Natchitoches	Beechwood Fish - Forest Hill
	Huey P. Long Fish - Lacombe
	James A. Noe Fish - Monroe
	Maine
Boothbay Harbor - Boothbay Harbor	Auburn - Route 1-A, Auburn
Craig Brook - East Orland	Caribou - Caribou
	Dry Mills - Dry Mills
	Enfield - Enfield
	Governor Hill - Route 4, Augusta
	Grand Lake Stream - Grand Lake Stream
	Littleton - RFD, Houlton

(Continued)

TABLE 1. (Continued)

Federal hatchery - Address	State hatchery - Address
	Maine (continued)
	Moosehead - Greenville Junction
	Oquossoc - Oquossoc
	Sebago - Raymond
	Tunk Pond - Cherryfield

	Rearing stations
	Appleton - RD 2, Liberty
	Birch River - Eagle Lake
	Carstunk - Carstunk
	Enfield - Enfield
	Gorham - Gorham
	Head Tide - Head Tide
	Kokadjo - Kokadjo
	LaGrange - LaGrange
	Lily Bay - Kokadjo
	Newport - Newport
	Phillips - Phillips
	Maryland
	Bear Creek Hatchery and Rearing Station - Accident
	Cushwa Rearing Station - Clear Spring
	Lewistown - Lewistown
	White Rock - Lewistown

	Tide Water Department Stations
	1 yellow perch hatchery - Severn River
	1 shad - Millington
	1 shad - Havre de Grace
	Massachusetts
Gloucester - Gloucester	East Sandwich State Fish - Sandwich
Hartsville - Great Barrington	Harold Parker State Forest Pond System - Andover
	Merrill State Pond System - Sutton
	Montague State Fish - Montague
	Palmer State Fish - Palmer
	Sandwich State Fish - Sandwich
	Sunderland State Fish - Sunderland
	Sutton State Fish - Sutton
	Michigan
Charlevoix - Charlevoix	Lake Gogebic State Fish - Watersmeet
Northville - Northville	Lydell State Fish - Comstock Park
	State Fish Hatchery - Benton Harbor
	Do. - Drayton Plains
	Do. - Grayling
	Do. - Harrietta
	Do. - Harrisville

(Continued)

TABLE 1. (Continued)

Federal hatchery - Address	State hatchery - Address
	Michigan (continued)
	State Fish Hatchery - Hastings
	Do. - Hillsdale
	Do. - Marquette
	Do. - Ogden
	Do. - Paris
	Do. - Watersmeet
	Wolf Lake State Fish - Mattawan

	Fish rearing stations
	Baldwin Rearing Station - Baldwin
	Bear Creek Rearing Station - Thompsonville
	Cook's Run Rearing Station - Beechwood
	Eckerman (L. Br. Tahquamenon River) - Eckerman
	Fenton Rearing Ponds - Fenton
	Fox River - Seney
	Otter River - Elo
	Platte River - Bendon
	Sturgeon River - Wolverine
	Minnesota
Homer - Homer	Bemidji (pike, sucker fry) - Bemidji
New London - New London	Crystal Springs Ponds (trout) - Altura
	Cut-Foot Sioux (pike, sucker fry) - Deer River
	Detroit Hatchery and Ponds (pike, sucker fry) - Detroit Lakes
	French River (pike, lake trout, whitefish) - French River
	Glenwood Hatchery and Ponds (pike, sucker fry) - Glenwood
	Hinckley Pond (pike) - Hinckley
	Hutchinson Pond (pike) - Hutchinson
	I. W. L. A. Pond (bass) - Minneapolis
	Jenkins (pike, sucker fry) - Pine River
	Lake of the Woods (pike) - Baudette
	Lanesboro Hatchery and Ponds (trout, bass) - Lanesboro
	Mills Lacs Pond (pike) - Nr. Garrison
	Park Rapids (pike, sucker fry) - Park Rapids
	Ranier (pike) - Ranier
	St. Croix Pond (bass) - Hinckley
	St. Paul Hatchery and Ponds (pike, trout) - St. Paul

(Continued)

TABLE 1. (Continued)

Federal hatchery - Address	State hatchery - Address
	Minnesota (continued)
	St. Peter (pike, suckers) - St. Peter
	Sturgeons Pond (pike) - Side Lake
	Tower (pike, sucker fry) - Tower
	Waskish (pike) - Waskish
	Windom Pond (pike, bass) - Windom
	Mississippi
Lyman - Lyman	
Meridian - Meridian	
Tupelo - Tupelo	
	Missouri
Bourbon - Bourbon	Bennett Spring - Bennett Spring
Neosho - Neosho	Chesapeake - Mt. Vernon
	Indian Trail - Salem
	Lewis and Clark - Rushville
	Montauk - Darien
	Roaring River - Cassville
	Sequiota - RFD, Springfield
	Taneycomo - Branson
	Montana
Bozeman - Bozeman	Anaconda State Fish - Anaconda
Creston - Creston	Big Timber State Fish - Big Timber
Ennis - Ennis	Emigrant State Fish - Emigrant
Miles City - Miles City	Great Falls State Fish - Great Falls
	Hamilton State Fish - Hamilton
	Lewistown State Fish - Lewistown
	Libby State Fish - Libby
	Arlee State Fish - Arlee
	Polson State Fish - Polson
	Somers State Fish - Somers
	McNiel Ponds - Malta
	Blue Waters Springs (under construction) - Fromberg
	---
	10 egg-collecting stations
	Nebraska
Crawford - Crawford	Gretna - Gretna
	North Platte - North Platte
	Rock Creek - Parks
	Valentine - Valentine
	Nevada
	Verdi Fish - Verdi

(Continued)

TABLE 1. (Continued)

Federal hatchery - Address	State hatchery - Address
	Nevada (continued)
	County hatcheries
	Elko County Fish - Ruby Valley
	Kenniscott Copper County (White Pine County) - McGill
	Washoe County Fish - Idlewild Park, Reno
	New Hampshire
Berlin - Berlin	Colebrook - Colebrook
Nashua - Nashua	Laconia - Laconia
	Merrimack Rearing Station - Merrimack
	New Hampton - New Hampton
	Newmarket Rearing Station - Newmarket
	Powder Mill Rearing Station - New Durham
	Warren - Warren
	Whitefield Rearing Station - Whitefield
	New Jersey
	Hackettstown - Hackettstown
	Musconetcong - Hackettstown
	New Mexico
Dexter - Dexter	Trout-cultural stations
Eagle Nest - Eagle Nest	Glenwood Hatchery and Rearing Ponds - Glenwood
Hot Springs - Box 671, Hot Springs	Lisbon Springs Hatchery and Rearing Ponds - Valley Ranch
Santa Rosa - Santa Rosa	Park View Hatchery, Rearing and Spawn-taking Station - Park View
	Red River Hatchery and Rearing Station - Questa
	Seven Springs Hatchery, Rearing and Spawn-taking Station - Jemez Springs
	New York
Cape Vincent - Cape Vincent	Adirondack - Saranac Inn
Carpenter's Brook - Elbridge	Bath - RFD, Bath
Cortland - Cortland	Caledonia - Mumford
	Chateaugay - Chateaugay
	Chautauqua - Bemus Point
	Cold Spring Harbor - Cold Spring Harbor
	Crown Point - Crown Point
	Dunkirk - Dunkirk
	Oneida - Constantia
	Randolph - Randolph
	Rome - RFD 6, Rome
	St. Lawrence - RFD 4, Ogdenburg

(Continued)

TABLE 1. (Continued)

Federal hatchery - Address	State hatchery - Address
	New York (continued)
	South Otselic - South Otselic
	Summitville - Summitville
	Warrensburg - Warrensburg
	Washington County - Cambridge

	Field stations or auxiliary hatcheries
	Johnstown - Johnstown
	Lake George at Fortsville - Gansevoort
	Lily Lake at Chenango Forks - Chenango Forks
	Van Hornesville - Van Hornesville
	North Carolina
Edenton - Edenton	Morrison (trout) - Balsam Gap, near Waynesville
Hoffman - Hoffman	Pete Murphy (trout, bass, bluegills) - Marion
Pisgah Forest - Pisgah Forest	Marmon (leased--trout) - Pineola
Smokemont - Smokemont	Roaring Gap (trout) - Roaring Gap
	Stedman (pondfish) - Fayetteville
	Table Rock (pondfish) - Morganton
	North Dakota
Valley City - Valley City	Lisbon - Lisbon
	Ohio
Hebron - Hebron	State Fish (jar hatchery) - Put-in-Bay
Senecaville - Hebron	State Fish Farm (pond hatchery) - St. Marys
	Do. - Newtown
	Do. - Indian Lake
	Do. - Xenia
	Do. - Akron
	Do. - Kincaid Springs
	Lake Rockwell (rearing lake) - Kent
	Meander Lake (rearing lake) - Mineral Bridge
	State Fish Transfer Depot and Freezer Plant - Sandusky
	Oklahoma
Tishomingo - Tishomingo	Byron - Byron
	Durant - Durant
	Heavener - Heavener
	Holdenville - Holdenville
	Medicine Park - Medicine Park
	Tahlequah - Tahlequah

(Continued)

TABLE 1. (Continued)

Federal hatchery - Address	State hatchery - Address
	Oregon
Delph Creek - Estacada	Alsea - Philomath
	Bandon - Bandon
	Brush Creek - Port Orford
	Butte Falls - Butte Falls
	Cedar Creek - Hebo
	Diamond Lake - Diamond Lake
	Fall River - Bend
	Hood River - Hood River
	Klamath - Klamath Agency
	McKenzie - Leaburg
	Oak Springs - Maupin
	Roaring River - Scio
	Rock Creek - Idleyld Park
	Wallowa - Enterprise
	Willamette - Oakridge

	Egg-taking stations
	Crane Prairie - Deschutes County
	East Lake - Deschutes County
	Elk Lake - Deschutes County
	Little Butte - Jackson
	Paulina - Deschutes
	Spencer Creek - Klamath

	Fish Commission of Oregon Hatcheries

(Station)	(Stream)	(Address)
No. 1	McKenzie River	Leaburg
No. 2	Willamette River	Oakridge
No. 3	Santian River	Stayton
No. 4	Columbia River	Bonneville
No. 5	Klaskamine River	Astoria
No. 6	Trask River	Tillamook
No. 7	Coos River	Marshfield
No. 8	Mill Creek	Scottsburg
No. 9	Umpqua River	Idleyld Park
No. 10	S. Santian River	Foster
No. 12	Ox Bow Springs	Cascade Locks
No. 13	Alsea River	Tidewater
No. 14	Ten Mile Lake	Hauser
No. 15	Coquille River	Powers
No. 16	Nehalen River	Mohler
No. 17	Yaquina River	Toledo
No. 18	Deschutes River	Maupin
No. 19	Siletz River	Nashville
No. 22	Sandy River	Sandy

(Continued)

TABLE 1. (Continued)

Federal hatchery - Address	State hatchery - Address
	Oregon (continued)
	No. 23 Siuslaw River Mapleton
	No. 24 Calapooya Creek Nonpareil
	No. 29 Tillasqua River Astoria
	Shad batteries
	Scappoose Columbia River Columbia
	Pennsylvania
Farnsworth - Clarendon	Bellefonte - Bellefonte
Lamar - Lamar	Corry - Corry
	Erie - Erie
	Huntsdale - Huntsdale
	Linesville - Linesville
	Pleasant Mount - Pleasant Mount
	Reynoldsdale - Reynoldsdale
	Tionesta - Tionesta
	Torresdale - Torresdale, Philadelphia
	Union City - Union City
	Rhode Island
Arcadia - Hope Valley	Goose Nest Spring (trout) - La Fayette
	Wickford (lobster) - Wickford
	South Carolina
Cheraw - Cheraw	Berry's Hill - Greer
Orangeburg County - Orangeburg	Buzzard Roost - Greenwood
Walhalla - Walhalla	Cleveland - Greenville
	Four-County - Newberry
	O'Neal - Greer
	Orangeburg - Orangeburg
	Richardson - Columbia
	Springs Stevens - Heath Springs
	Table Rock - Pickens
	Toney Tucker - Anderson
	South Dakota
Spearfish - Spearfish	Claghorn Springs Trout - Rapid City
	Lake Andes (largemouth black bass) - Lake Andes
	Lake Byron - Huron
	Lakeside - Redfield
	Pickerel Lake (pike, sunfish, bass, perch) - Webster
	Twin Lakes - Woonsocket
	Tennessee
Erwin - Erwin	Flintville - Flintville
	Morristown - Morristown
	Springfield - Springfield

(Continued)

TABLE 1. (Continued)

Federal hatchery - Address	State hatchery - Address
	Texas
Austin - Box 1043, Austin	Cisco - Cisco
Fort Worth - Fort Worth	Dundee - Dundee
Inks Dam - Route 2, Burnet	Eagle Mountain - Azle, Star Route, Fort Worth
San Angelo - San Angelo	Huntsville - Huntsville
San Marcos - San Marcos	Ingram - Ingram
Uvalde - Uvalde	Jasper - Jasper
	Lake Dallas - Lake Dallas
	Medina Lake - Natalia
	Olmito - Olmito
	Tyler - Tyler
	Utah
Springville - Springville	Beaver - Beaver
	Fish Lake - Fish Lake
	Fountain Green Rearing Station - Fountain Green
	Glenwood Hatchery and Rearing Station - Glenwood
	Kamas Hatchery and Rearing Station - Kamas
	Loa - Loa
	Logan - Logan
	Midway - Charleston
	Morgan - Morgan
	Panguitch - Panguitch
	Salt Lake - 880 Scott Avenue, Salt Lake City
	Springville Hatchery and Rearing Station - Springville
	Whiterocks - Whiterocks
	Vermont
Pittsford - Pittsford	Bennington - Bennington
St. Johnsbury - St. Johnsbury	Canaan - Canaan
	Roxbury - Roxbury
	Salisbury - Salisbury

	Fish rearing stations
	Danby Pools - Danby
	Hardwick Pools - Hardwick
	Hartford Pools - White River Junction
	Newport Stripping - Newport
	Randolph Pool - Randolph
	Shaftsbury Pools - Shaftsbury
	South Vernon Pools - South Vernon
	Wallingford Pools - Wallingford

(Continued)

TABLE 1. (Continued)

Federal hatchery - Address	State hatchery - Address
	Virginia
Ft. Belvoir - Ft. Belvoir	Front Royal - Waterlick
Harrison Lake - Westover	King and Queen - Stevensville
New Castle - New Castle	Marion - Marion
Wytheville - Wytheville	Montebelle Rearing Station - Montebelle
	Washington
Big White Salmon - Underwood	Salmon hatcheries
Carson - Carson	Bowman's Bay Salt Water - Deception Pass State Park, Anacortes
Entiat - Entiat	Cowlitz River - Box 74, Packwood
Leavenworth - Leavenworth	Dungeness - Box 8, Sequim
Little White Salmon - Cook	Green River - Route 1, Box 740, Auburn
Quilcene - Quilcene	Issaquah - Issaquah
Winthrop - Winthrop	Kalama - Route 1, Box 159, Kalama
	Lewis River - Woodland
	Lewis River Sub-station - Cougar
	Minter Creek - Star Route, Gig Harbor
	Naselle River - Naselle
	Puyallup River - Orting
	Samish - Route 2, Sedro Woolley
	Skagit - Box 156, Marblemount
	Skykomish - Startup
	Willapa - Route 1, Box 282, Raymond

	Game-fish hatcheries
	Aberdeen - RFD 1, Montesano
	Bellingham - Whatcom Falls Park, Bellingham
	Arlington - Arlington
	Chelan - Chelan
	Chiwaukum - Winton
	Colville - Colville
	Ford - Ford
	Goldendale - Goldendale
	Lake Whatcom - RFD 2, Sedro Woolley
	Mason County - Shelton
	Mossyrock - Mossyrock
	Naches - RFD 1, Naches
	Pend Oreille - Usk
	Puyallup - Puyallup
	San Poil - Republic
	Seward Park Ponds - Seward Park, Seattle
	South Tacoma - RFD 1, Box 141, South Tacoma
	Spokane - RFD 7, Spokane
	Tokul Creek - RFD 1, North Bend
	Vancouver - RFD 1, Box 217-A, Vancouver

(Continued)

TABLE 1. (Continued)

Federal hatchery - Address	State hatchery - Address
	Washington (continued)
	Walla Walla - RFD 3, Walla Walla
	Yakima - RFD 7, Yakima

	Spawning and egg-taking station
	Chelan Twin Lakes Eyeing Station - c/o Chelan Hatchery, Winton
	West Virginia
Leetown - Kearneysville	Marlinton Trout - Marlinton
Moorefield - Kearneysville	Palestine Bass - Palestine
White Sulphur Springs - White Sulphur Springs	Petersburg Trout - Petersburg
	Ridge Bass - Ridge
	Wisconsin
Genoa - Genoa	Bayfield - Bayfield
La Crosse - La Crosse	Birchwood - Birchwood (Spooner)*
Lake Mills - Lake Mills	Brule - Brule
	Burlington Flowage - Burlington
	Chippewa Flowage - Winter (Spooner)
	Crystal Springs - Deerbrook
	Delafield - Delafield
	Eagle River - Eagle River (Woodruff)
	Hartman Creek - Waupaca
	Hayward (trout) - Hayward
	Island Lake - New Auburn (Spooner)
	Lakewood - Lakewood (Woodruff)
	Langlades - White Lake (Woodruff)
	Little Thunder River Falls - Crivitz
	Madison - Route 3, Madison
	Manitowish - Woodruff
	Mercer - Mercer (Woodruff)
	Osceola - Osceola
	Sayner - Woodruff
	Spooner - Spooner
	St. Croix Falls - St. Croix Falls
	Sturgeon Bay - Sturgeon Bay
	Westfield - Westfield
	Weyauwega - Weyauwega (Madison)
	Wild Rose - Wild Rose
	Woodruff - Woodruff

	Fish rearing units
	Blair Pond - Blair (Madison)
	Conover Pond - Woodruff
	DeSoto Pond - De Soto (Madison)

*Post-office address () during period of the year when the hatchery is not in operation.

(Continued)

TABLE 1. (Continued)

Federal hatchery - Address	State hatchery - Address
	Wyoming
Saratoga - Saratoga	Cody Hatchery and Rearing Station - Cody
Yellowstone Park - Yellowstone Park (10/16 to 5/30, Bozeman, Mont.)	Como Bluff Hatchery and Rearing Station - Rock River
	Daniel Hatchery and Rearing Station - Daniel
	Dubois - Dubois
	Glenrock Rearing Station - Glenrock
	Story - Story
	Tensleep Hatchery and Rearing Station - Tensleep
	Western Wyoming Hatchery and Rearing Station - Afton

	Egg-taking stations
	Cook Lake - Daniel
	Jakey's Fork - Dubois
	Lake DeSmet - Story
	Shoshone Lake - Lander
	West Tensleep Lake - Tensleep

first survey, additional units were probably contemplated but were postponed for lack of funds during the early years of the depression. In the late 1930's, relief labor and funds from such agencies as the C.C.C., W.P.A., and P.W.A., permitted, and in fact encouraged, the construction of fish hatcheries. Beginning about 1940, the farm-pond program and the attendant requirement for warm-water fish encouraged the construction of at least a few new hatcheries. Similarly, the trend toward the rearing of catchable-size instead of fingerling trout created need for additional hatcheries and the remodeling of older units.

Some hatcheries have been abandoned for one reason or another. In comparing the 1937 list with the present one, it has been noted that 116 no longer appear as being in operation. The 32-percent increase in the number of hatcheries operated accounts for only the additional ones; in terms of new construction, 116 units would have to be considered as replacements.

The production of fish, as reported by 37 States and the Fish and Wildlife Service, is presented in tables 2, 3, 4, and 5. As the 1937 survey is the only one available to show fish production on a nation-wide basis, that survey may be used for certain comparisons. The number of States reporting on each of the surveys remains the same; however, seven States that reported in 1937 have been unable to do so for the present survey at time of writing, and seven States that were unable to report in 1937 have done so now. In the present survey, the States were requested to indicate their fish production in terms of fry, fingerlings, and 6 inches and more in size. It should be pointed out that those States that have 7-inch size limits and that reported their production accordingly, may have produced 6-inch fish which would be included in the fingerling group.

The total number of fish produced by the reporting agencies decreased by more than one-half in the period 1937 to 1948. Of the total number of fish produced, 91

TABLE 2.--Distribution of fish from hatcheries of 37 States

State and Year	Species	Fry	Fingerling	6 inches and more	Total
Alabama	Bass	-	389,993	-	389,993
10/1/47 to 9/30/48	Bream	-	3,692,783	-	3,692,783
	Crappie	-	300	-	300
Arizona	Rainbow	827,280	116,580	368,414	1,312,274
7/1/46 to 6/30/47	Grayling	450,000	-	-	450,000
	Cutthroat	645,120	111,740	-	756,860
	Brown	-	-	3,495	3,495
	Brook	-	-	57,700	57,700
	Largemouth Bass	-	85,249	-	85,249
	Smallmouth Bass	-	2,900	-	2,900
	Bluegill	-	120,502	-	120,502
	Channel Catfish	-	8,000	-	8,000
Arkansas	Largemouth Bass	-	1,518,532	-	1,518,532
7/1/47 to 6/30/48	Smallmouth Bass	-	114,175	-	114,175
	Bluegill Bream	-	2,079,593	-	2,079,593
	Red-eared Bream	-	18,020	-	18,020
	Crappie	-	101,888	-	101,888
	Bullhead Catfish	-	15,250	-	15,250
	Channel Catfish	-	69,250	-	69,250
	Top Minnow	-	30,000	-	30,000
	Golden Shiner	-	40,740	-	40,740
	Bullfrog Tadpole	-	10,000	-	10,000
	Rainbow Trout	-	6,325	-	6,325
	Brown Trout	-	9,050	-	9,050
	Rock Bass	-	1,000	-	1,000
	Salvage:				
	Carp	-	167,500	-	167,500
	Crappie	-	345,000	-	345,000
	Bluegill Bream	-	356,000	-	356,000
	Largemouth Bass	-	200,500	-	200,500

(Continued)

TABLE 2. (Continued)

State and Year	Species	Fry	Fingerling	6 inches and more	Total
Arkansas (continued)	Buffalo	-	210,100	-	210,100
	Channel Catfish	-	55,200	-	55,200
California 1/1/47 to 12/31/47	Rainbow	-	14,199,614	3,000,000	17,199,614
	Steelhead	-	1,595,860	-	1,595,860
	Brown	-	882,790	-	882,790
	Eastern Brook	-	1,753,018	-	1,753,018
	Black-spotted	-	329,900	-	329,900
	Cutthroat	-	33,610	-	33,610
	King Salmon	-	3,733,050	-	3,733,050
	Silver Salmon	-	14,015	-	14,015
	Kokanee	-	457,800	-	457,800
	Spiny-rayed Fishes	-	573,789	-	573,789
Connecticut 7/1/46 to 6/30/47	Brook Trout	202,966	118,110	269,384	590,460
	Brown Trout	157,120	110,693	88,983	356,796
	Rainbow Trout	-	28,395	63,564	91,959
Florida 1/1/47 to 12/31/48	Largemouth Bass	-	587,000	-	587,000
	Bream (Bluegill, Red-ear, and Red-breast)	-	3,959,600	-	3,959,600
	Black Crappie	-	112,000	-	112,000
Georgia Fiscal 1947-1948	Bass	500,000	-	-	500,000
	Sunfish	2,500,000	-	-	2,500,000
	Trout (Rainbow, Brown, and Brook)	-	-	500,000	500,000
Idaho 1/1/47 to 12/31/47	Cutthroat	-	7,586,000	274,000	7,860,000
	Eastern Brook	-	1,060,000	50,000	1,110,000
	Rainbow	-	5,713,000	357,000	6,070,000
	Blueback Salmon	-	490,000	-	490,000
	Smallmouth Bass	-	1,750	-	1,750
	Lake Trout	-	-	8,500	8,500

TABLE 2. (Continued)

State and Year	Species	Fry	Fingerling	6 inches and more	Total
Illinois	Wall-eyed Pike	10,000,000	-	-	10,000,000
1/1/47 to 12/31/47	Trout	-	-	34,000	34,000
	Bass and Bluegill	-	1,225,803	-	1,225,803
	Bass, Bluegill, Perch, Bullhead, Crappie, etc.	-	13,193	526,461	539,654
Indiana	Largemouth Bass	-	-	239,843	239,843
7/1/46 to 6/30/47	Smallmouth Bass	-	194,450	-	194,450
	Southern Smallmouth Bass	-	9,400	-	9,400
	Rock Bass	-	161,109	-	161,109
	Bluegill	-	587,746	-	587,746
	Red-eared Sunfish	-	488,890	-	488,890
	Crappie	-	69,520	-	69,520
	Channel Catfish	-	-	26,255	26,255
	Rainbow Trout	-	-	6,099	6,099
	Brown Trout	-	50,564	-	50,564
Iowa	Catfish	-	-	12,346	12,346
7/1/45 to 6/30/46	Bullhead	-	63,380	600,000	663,380
	Largemouth Bass	-	75,498	-	75,498
	Smallmouth Bass	-	7,628	-	7,628
	Rainbow Trout	-	-	85,085	85,085
	Brown Trout	-	-	43,705	43,705
	Brook Trout	-	-	10,445	10,445
	Crappie	-	309,246	-	309,246
	Bluegill	-	418,239	-	418,239
	Walleye	81,841,267	51,000	-	81,892,267
	Yellow Perch	-	124,276	-	124,276
	Yellow Bass	-	453	-	453
	Northern Pike	-	500	-	500
	Minnow	-	93,273	-	93,273
Kentucky	Kentucky and	897,938	155,145	-	1,053,083
7/1/46 to 6/30/47	Largemouth Bass				

(Continued)

TABLE 2. (Continued)

State and Year	Species	Fry	Fingerling	6 inches and more	Total
Kentucky (continued)	Yellow Pike Perch	880,000	-	-	880,000
	Bream	-	-	209,908	209,908
	Crappie	-	-	40,904	40,904
	Other species (Green Sunfish, Catfish, Carp, and Shad)	-	-	119,630	119,630
Maine 1946 to 1947	Brook Trout	1,500,000	2,308,001	1,100,000	4,908,001
	Brown Trout	-	200,000	221,500	421,500
	Rainbow Trout	-	-	1,300	1,300
	Bass	-	30,000	-	30,000
	Sockeye Salmon	393,500	200,000	-	593,500
	Landlocked Salmon	2,000,000	1,000,000	347,700	3,347,700
	Togue	-	30,731	-	30,731
Maryland 7/1/46 to 6/30/47	Trout (Brook, Brown, and Rainbow)	-	47,600	56,200	103,800
	Largemouth Bass	-	7,939	32,762	40,701
	Smallmouth Bass	-	-	7,400	7,400
	Crappie	-	1,485	350	1,835
	Sunfish	-	9,600	-	9,600
	Yellow Perch	10,800,000	-	265	10,800,265
	Pike	-	-	23	23
Massachusetts 7/1/47 to 6/30/48	Brook Trout	-	17,400	373,349	390,749
	Brown Trout	-	25,600	72,436	98,036
	Rainbow Trout	-	5,315	144,295	149,610
	Smallmouth Bass	-	60,000	-	60,000
	Yellow Perch	-	80,750	22,125	102,875
	Horned Pout	-	186,900	62,715	249,615
	Pickerel	-	-	12,978	12,978
	Calico Bass	-	23,900	8,935	32,835

TABLE 2. (Continued)

State and Year	Species	Fry	Fingerling	6 inches and more	Total
Michigan	Brook Trout	-	345,833	408,094 [1]	753,927
1/1/47 to 12/31/47	Brown Trout	-	509,605	271,044	780,649
	Rainbow Trout	-	273,680	283,302	556,982
	Lake Trout	-	-	48,350	48,350
	Smallmouth Bass	-	54,502	7	54,509
	Largemouth Bass	-	20,880	-	20,880
	Bluegill	-	20,300	-	20,300
	Pike-perch	-	250	6,102	6,352
	Great Northern Pike	-	-	6	6
Missouri	Largemouth Black Bass	-	1,356,135	-	1,356,135
7/1/46 to 6/30/47	Smallmouth Black Bass	-	292,125	-	292,125
	Crappie	-	248,335	-	248,335
	Bluegill	-	1,525,535	-	1,525,535
	Green Sunfish	-	398,345	-	398,345
	Channel Catfish	-	251,476	-	251,476
	Bullhead Catfish	-	215,160	-	215,160
	Goggle-eye	-	71,000	-	71,000
	Minnow	-	34,110	-	34,110
	Trout	-	277,326	-	277,326
Montana	Rainbow	1,460,000	-	1,363,000	2,823,000
5/1/47 to 4/30/48	Black-spotted	3,449,000	-	478,000	3,927,000
	Loch Leven	1,335,000	-	465,000	1,800,000
	Eastern Brook	538,000	-	226,000	764,000
	Grayling	2,000,000	-	25,000	2,025,000
	Sockeye Salmon	4,220,000	-	-	4,220,000
Nebraska	Br. Trout	60,399	-	405	60,804
1/1/47 to 12/31/47	Rainbow Trout	-	-	88,528	88,528
	Bullhead	800	154,744	29,087	184,631
	Bluegill	154,790	45,302	958	201,050
	Crappie	2,750	161,505	1,031	165,286
	Bass	1,355	95,466	316	97,137

(Continued)

TABLE 2. (Continued)

State and Year	Species	Fry	Fingerling	6 inches and more	Total
Nebraska (continued)	Catfish	-	54,100	-	54,100
	Wall-eyed Pike	651,662	190,934	-	842,596
New Hampshire 1/1/47 to 12/31/47	Brook Trout	1,083,000	315,402	587,969	1,986,371
	Rainbow Trout	-	35,000	59,514	94,514
	Lake Trout	1,145,000	22,600	26,125	1,193,725
	Aureolus Trout	-	-	5,957	5,957
	Brown Trout	-	37,000	67,584	104,584
	Landlocked Salmon	-	2,000	28,840	30,840
New Jersey 7/1/47 to 6/30/48	Trout (Brook, Brown, and Rainbow)	-	7,000	444,273	451,273
	Bass (Largemouth and Smallmouth)	-	262,370	7,632	270,002
	Bluegill Sunfish	-	183,230	1,625	184,855
	Tadpoles	10,000	-	-	10,000
New Mexico 7/1/47 to 6/30/48	Rainbow	-	1,978,015	556,267	2,534,282
	Loch Leven	-	361,572	16,342	377,914
	Yellowstone Cutthroat	-	727,491	-	727,491
	New Mexican Native Cutthroat	-	74,610	2,332	76,942
New York 4/1/47 to 3/31/48	Brown Trout	-	1,515,362 [2]	217,823 [1]	1,733,185
	Rainbow Trout	-	260,344	8,061	268,405
	Lake Trout	-	1,103,872	-	1,103,872
	Brook Trout	-	2,762,425	159,841	2,922,266
	Atlantic Salmon	-	18,450	111	18,561
	Landlocked Salmon	-	1,508	18	1,526
	Bullhead Catfish	-	1,046	-	1,046
	Calico Bass	-	-	5,400	5,400
	Largemouth Bass	20,000	-	-	20,000
	Muskellunge	5,437,150	-	14,226	5,451,376
	Pike-perch	464,144,000	-	-	464,144,000

(Continued)

TABLE 2. (Continued)

State and Year	Species	Fry	Fingerling	6 inches and more	Total
New York (continued)	Smallmouth Bass	680,000	113,962	-	793,962
	Whitefish	4,326,000	-	-	4,326,000
North Carolina 7/1/47 to 6/30/48	Brook	-	30,406	52	30,458
	Rainbow	-	55,789	515	56,304
	Brown	-	10,200	116	10,316
	Largemouth Bass	37,000	76,820	107	113,927
	Smallmouth Bass	-	4,800	-	4,800
	Bluegill	-	157,087	162	157,249
	Redbreast	-	6,500	19	6,519
	Crappie	-	370	-	370
North Dakota 7/1/47 to 7/1/48	Wall-eyed Pike	6,750,000	36,400	12	6,786,412
	Catfish	-	-	1,121	1,121
	Bluegill	-	206,125	228	206,353
	Black Bass	-	67,210	25	67,235
	Bullhead	-	10,000	1,004	11,004
	Crappie	-	7,066	1,907	8,973
	Sunfish	-	6,166	8	6,174
	Northern Pike	-	375	4,385	4,760
	Golden Shiner	-	2,000	-	2,000
	Perch	-	7,066	200	7,266
Ohio 1/1/47 to 12/31/47	Yellow Pike Perch	78,680,000	-	650	78,680,650
	Whitefish	123,280,000	-	-	123,280,000
	Largemouth Bass	-	116,461	2,109	118,570
	Smallmouth Bass	-	42,799	372	43,171
	Spotted Bass	-	4,305	-	4,305
	Rock Bass	-	97,086	186	97,272
	Bluegill	-	31,530	63,826	95,356
	Bullhead Catfish	-	46,829	1,080	47,909
	Channel Catfish	-	-	31,970	31,970
	Mixed Catfish	-	-	5,092	5,092
	Mixed Sunfish	-	-	196	196

(Continued)

TABLE 2. (Continued)

State and Year	Species	Fry	Fingerling	6 inches and more	Total
Ohio (continued)	Forage and Rough Fish	-	-	5,443	5,443
	Crappie	-	-	22,285	22,285
	Goldfish	-	-	270	270
	Yellow Perch	-	-	14,303	14,303
Oklahoma 7/1/47 to 6/30/48	Bass	357,450	482,820	160,940	1,001,210
	Channel Catfish	-	556,449	-	556,449
	Red-ear	-	180,015	-	180,015
	Bluegill	-	793,810	-	793,810
	Crappie	-	583,230	-	583,230
	Miscellaneous	-	133,730	-	133,730
	Minnow	-	-	30,650	30,650
Oregon 1/1/47 to 12/31/47	Cutthroat	34,620	1,066,621	430,065	1,531,306
	Chum Salmon	52,540	-	-	52,540
	Yanks	180,800	-	-	180,800
	Chinook	547,400	243,600	-	791,000
	Silver	282,200	191,623	150,000	623,823
	Steelhead	965,495	1,138,131	85,000	2,188,626
	Eastern Brook	627,410	1,060,713	164,346	1,852,469
	Rainbow, Spring Spawn.	6,593,491	581,293	7,310	7,182,094
	Rainbow, Fall Spawn.	-	3,274,782	1,420,000	4,694,782
Pennsylvania 1/1/47 to 12/31/47	Trout	-	2,954,590	2,075,522	5,030,112
	Black Bass	-	613,225	6,982	620,207
	Bream	-	231,445	37,575	269,020
	Catfish	-	129,093	35,567	164,660
	Yellow Perch	146,912,500	184,640	8,631	147,105,771
	Pike Perch	8,020,000	-	-	8,020,000
	Pickerel	-	-	1,696	1,696
	Sucker	-	18,807	-	18,807
	Minnow	-	74,350	-	74,350
	Calico Bass	-	-	1,300	1,300
	Goldfish	-	35	-	35

(Continued)

TABLE 2. (Continued)

State and Year	Species	Fry	Fingerling	6 inches and more	Total
Pennsylvania (cont'd)	Whitefish	2,516,000	-	-	2,516,000
	Cisco	5,400,000	-	-	5,400,000
	Frog Tadpole	-	544,720	-	544,720
	Salvage:				
	Carp	-	-	108,066	108,066
	Catfish	-	-	107,075	107,075
	Pike Perch	-	-	2,233	2,233
Rhode Island 7/1/47 to 6/30/48	Brook Trout	-	15,000 [3]	45,000 [1]	60,000
	Brown Trout	-	-	3,000	3,000
South Carolina 6/30/46 to 7/1/47	Largemouth Bass, Bluegilled Bream, Crappie, and Catfish	-	3,377,931	-	3,377,931
Texas 9/1/46 to 9/1/47	Crappie	-	456,929	-	456,929
	Sunfish	-	1,714,153	-	1,714,153
	Warmouth Bass	-	134,345	-	134,345
	Channel Catfish	-	1,182,978	-	1,182,978
	Largemouth Black Bass	-	14,137,196	-	14,137,196
Virginia 7/1/47 to 6/30/48	Brook and Rainbow Trout	-	-	274,467	274,467
	Smallmouth Bass	-	10,500	-	10,500
	Largemouth Bass	-	-	44,717	44,717
	Rock Bass	-	37,000	-	37,000
	Sunfish	-	101,000	-	101,000
	Bluegill Bream	-	86,400	22,500	108,900
	Crappie	-	44,400	-	44,400
Washington 4/1/47 to 3/31/48	Cutthroat	1,975,422	664,169 [4]	-	2,639,591
	Eastern Brook	791,808	200,308	-	992,116
	Rainbow	5,324,458	6,992,500	-	12,316,958
	Silver Trout	43,162,194	53,768	-	43,215,962
	Steelhead	103,840	624,887	-	728,727

(Continued)

TABLE 2. (Continued)

State and Year	Species	Fry	Fingerling	6 inches and more	Total
Washington (cont'd)	Silver Salmon	35,200	216,572)	-	251,772
	Grayling	44,000	-)	-	44,000
1/1/47 to 12/31/47	Chinook Salmon	6,124,576	8,672,870	53,047	14,850,493
	Silver Salmon	855,777	7,622,699	31,800	8,510,276
	Chum Salmon	382,102	-	-	382,102
	Sockeye Salmon	-	32,127	-	32,127
	Steelhead Trout	-	-	20,766	20,766
West Virginia	Brook, Rainbow, and Brown Trout	-	946,525	178,324	1,124,849
7/1/47 to 7/1/48	Bluntnose and Blackhead Minnow	-	2,455,000	-	2,455,000
	Crappie	-	180,000	-	180,000
	Bluegill Sunfish	-	276,000	-	276,000
	Smallmouth Bass	-	44,260	-	44,260
	Largemouth Bass	-	-	250	250
Wisconsin	Brook Trout	77,957	2,155,406	461,589	2,694,952
1/1/47 to 12/31/47	Brown Trout	-	1,787,032	398,977	2,186,009
	Rainbow Trout	-	560,269	94,764	655,033
	Lake Trout	897,800	141,000	-	1,038,800
	Bluegill	-	263,386	12,280	275,666
	Bullhead	-	396,224	10,210	406,434
	Catfish	-	-	1,968	1,968
	Crappie	-	9,958	9,375	19,333
	Muskellunge Hybrid	-	-	128	128
	Largemouth Black Bass	-	934,912	5,692	940,604
	Muskellunge	4,981,546	227,293	158	5,208,997
	Northern Pike	11,217,674	3,043	643	11,221,360
	Perch	-	76,421	3,212	79,633
	Smallmouth Black Bass	-	425,100	55	425,155
	Sucker	-	-	3,545	3,545
	Sunfish	-	6,005	-	6,005
	Walleye	303,666,988	870,809	2,329	304,540,126

(Continued)

TABLE 2. (Continued)

State and Year	Species	Fry	Fingerling	6 inches and more	Total
Wisconsin (cont'd)	Red Horse	-	-	11	11
	Shiner	-	5,000	-	5,000
	Fathead	-	12,000	-	12,000
Wyoming 1/1/47 to 12/31/47	Albino Brook Trout	-	-	2,240	2,240
	Brook Trout	124,211	782,741	8,849	915,801
	Brown Trout	31,000	113,031	22,911	166,942
	Cutthroat Trout	2,390,596	1,065,125	8,409	3,464,130
	Golden Trout	3,856	-	-	3,856
	Mackinaw Trout	-	57,113	-	57,113
	Rainbow Trout	778,162	759,286	42,544	1,579,992
	Largemouth Bass	-	160	260	420
	Black Bullhead	-	-	3,235	3,235
	Bluegill	-	600	-	600
	Crappie	-	330	-	330
	Perch	-	1,500	-	1,500
	Forage Fish	-	39,427	-	39,427
Totals		1,368,520,170	154,964,405	22,122,080	1,545,606,655

[1] 7 inches and more.
[2] 1- to 7-inch fingerling.
[3] 4-inch fingerling.
[4] Approximately 75 percent of the fingerlings released are over 6 inches.

TABLE 3.--Summary of fish distribution, by species, from hatcheries of the Fish and Wildlife Service during 1947

Species	Fry	Fingerling	6 inches and more	Total
Bass,				
Largemouth Black	2,031,848	5,700,196	17,284	7,749,328
Rock	-	14,042	135	14,177
Smallmouth Black	851,000	185,653	10,656	1,047,309
Striped	7,756,000	-	-	7,756,000
Warmouth	-	20,348	20	20,368
Buffalo	-	10,000	500	10,500
Catfish,				
Channel	130,750	136,852	1,041	268,643
Yellow	-	4,185	-	4,185
Unclassified	-	362,678	11,683	374,361
Crappie	-	267,689	3,168	270,857
Flounder	1,136,737,865	-	-	1,136,737,865
Grayling	-	43,138	5,016	48,154
Lobster	1,164,300	-	-	1,164,300
Perch,				
White	1,950,000	-	-	1,950,000
Yellow	-	33,521	-	33,521
Pike-perch	13,250,597	58,014	10,666	13,319,277
Salmon,				
Atlantic	-	75,775	74,506	150,281
Chum	8,021,440	-	-	8,021,440
King	26,851,750	31,136,140	-	57,987,890
Red	-	3,994,171	79,812	4,073,983
Sebago	-	-	30,801	30,801
Silver	-	1,775,865	-	1,775,865
Shad	14,311,000	1,500	-	14,312,500
Sunfish,				
Bluegill	-	34,514,092	22,492	34,536,584
Green	-	56,500	-	56,500
Red-ear	-	489,284	1,099	490,383
Terrapin	7,000	-	-	7,000
Trout,				
Brown	75,860	1,623,871	220,593	1,920,324
Cutthroat	3,896,540	2,581,169	14,750	6,492,459
Eastern Brook	903,987	3,764,622	459,444	5,128,053
Lake	108,100	508,296	857	617,253
Rainbow	207,650	5,224,621	794,394	6,226,665
Steelhead	-	263,291	-	263,291
Totals	1,218,255,687	92,845,513	1,758,917	1,312,860,117

TABLE 4.--Summary of fish distribution from hatcheries of 37 States and the Fish and Wildlife Service

Source	Fry	Fingerling	6 inches and more	Total
Alabama	-	4,083,076	-	4,083,076
Arizona	1,922,400	444,971	429,609	2,796,980
Arkansas	-	5,348,123	-	5,348,123
California	-	23,573,446	3,000,000	26,573,446
Connecticut	360,086	257,198	421,931	1,039,215
Florida	-	4,658,600	-	4,658,600
Georgia	3,000,000	-	500,000	3,500,000
Idaho	-	14,850,750	689,500	15,540,250
Illinois	10,000,000	1,238,996	560,461	11,799,457
Indiana	-	1,561,679	272,197	1,833,876
Iowa	81,841,267	1,143,493	751,581	83,736,341
Kentucky	1,777,938	155,145	370,442	2,303,525
Maine	3,893,500	3,768,732	1,670,500	9,332,732
Maryland	10,800,000	66,624	97,000	10,963,624
Massachusetts	-	399,865	696,833	1,096,698
Michigan	-	1,225,050	1,016,905	2,241,955
Missouri	-	4,669,547	-	4,669,547
Montana	13,002,000	-	2,557,000	15,559,000
Nebraska	871,756	702,051	120,325	1,694,132
New Hampshire	2,228,000	412,002	775,989	3,415,991
New Jersey	10,000	452,600	453,530	916,130
New Mexico	-	3,141,688	574,941	3,716,629
New York	474,607,150	5,776,969	405,480	480,789,599
North Carolina	37,000	341,972	971	379,943
North Dakota	6,750,000	342,408	8,890	7,101,298
Ohio	201,960,000	339,010	147,782	202,446,792
Oklahoma	357,450	2,730,054	191,590	3,279,094
Oregon	9,283,956	7,556,763	2,256,721	19,097,440
Pennsylvania	162,848,500	4,750,905	2,384,647	169,984,052
Rhode Island	-	15,000	48,000	63,000
South Carolina	-	3,377,931	-	3,377,931
Texas	-	17,625,601	-	17,625,601
Virginia	-	279,300	341,684	620,984
Washington	58,799,377	25,079,900	105,613	83,984,890
West Virginia	-	3,901,785	178,574	4,080,359
Wisconsin	320,841,965	7,873,858	1,004,936	329,720,759
Wyoming	3,327,825	2,819,313	88,448	6,235,586
	1,368,520,170	154,964,405	22,122,080	1,545,606,655
Fish and Wildlife Service	1,218,255,687	92,845,513	1,758,917	1,312,860,117
Totals	2,586,775,857	247,809,918	23,880,997	2,858,466,772

TABLE 5.--Summary of fish distribution, by species, from hatcheries of the Fish and Wildlife Service and of 37 States

Species	Fry	Fingerling	6 inches and more	Total
Bass,				
Largemouth Black	2,986,786	24,972,623	343,024	28,302,433
Rock	-	381,237	321	381,558
Smallmouth Black	1,531,000	1,564,004	18,490	3,113,494
Spotted Black	-	4,305	-	4,305
Striped	7,756,000	-	-	7,756,000
Warmouth	-	154,693	20	154,713
Yellow	-	453	-	453
Unclassified	858,805	1,941,084	175,895	2,975,784
Buffalo	-	220,100	500	220,600
Bullhead,				
Black	-	-	3,235	3,235
Brown	800	1,089,533	704,096	1,794,429
Carp	-	167,500	108,066	275,566
Catfish,				
Channel	130,750	2,260,205	59,266	2,450,221
Yellow	-	4,185	-	4,185
Unclassified	-	545,871	174,852	720,723
Cisco	5,400,000	-	-	5,400,000
Crappie				
Black	-	135,900	15,635	151,535
Unclassified	2,750	2,787,251	79,020	2,869,021
Flounder	1,136,737,865	-	-	1,136,737,865
Goldfish	-	35	270	305
Grayling	2,494,000	43,138	30,016	2,567,154
Lobster	1,164,300	-	-	1,164,300
Minnow,				
Bluntnose and Fathead	-	2,455,000	-	2,455,000
Fathead	-	12,000	-	12,000
Top	-	30,000	-	30,000
Unclassified	-	201,733	30,650	232,383
Muskellunge	10,418,696	227,293	14,512	10,660,501
Perch,				
White	1,950,000	-	-	1,950,000
Yellow	157,712,500	423,187	45,324	158,181,011
Unclassified	-	84,987	3,412	88,399
Pickerel	-	-	14,674	14,674
Pike,				
Great Northern	11,217,674	3,918	5,034	11,226,626
Wall-eyed	402,909,917	1,149,143	2,341	404,061,401
Unclassified	-	-	23	23
Pike-Perch,				
Yellow	79,560,000	-	650	79,560,650
Unclassified	485,414,597	58,264	19,001	485,491,862
Salmon,				
Atlantic	-	94,225	74,617	168,842
Chum	8,456,082	-	-	8,456,082
King	33,523,726	43,785,660	53,047	77,362,433
Kokanee	-	457,800	-	457,800
Red	4,794,300	4,716,298	79,812	9,590,410

(Continued)

TABLE 5. (Continued)

Species	Fry	Fingerling	6 inches and more	Total
Salmon (continued)				
Sebago	2,000,000	1,003,508	407,359	3,410,867
Silver	1,173,177	9,820,774	181,800	11,175,751
Shad	14,311,000	1,500	-	14,312,500
Shiner,				
Golden	-	42,740	-	42,740
Unclassified	-	5,000	-	5,000
Sucker,				
Red Horse	-	-	11	11
Unclassified	-	18,807	3,545	22,352
Sunfish,				
Bluegill	154,790	41,665,477	124,071	41,944,338
Green	-	454,845	-	454,845
Red-ear	-	1,176,209	1,099	1,177,308
Yellow-belly	-	6,500	19	6,519
Unclassified	2,500,000	9,720,752	247,687	12,468,439
Tadpoles	10,000	554,720	-	564,720
Terrapin	7,000	-	-	7,000
Trout,				
Brown	1,659,379	7,236,370	2,113,914	11,009,663
Cutthroat	12,391,298	14,240,435	1,207,556	27,839,289
Eastern Brook	5,849,339	16,689,385	4,384,302	26,923,026
Golden	3,856	-	-	3,856
Lake	2,150,900	1,863,612	83,832	4,098,344
Rainbow	15,191,041	40,064,808	8,743,956	63,999,805
Silver	43,162,194	53,768	-	43,215,962
Steelhead	1,069,335	3,622,169	105,766	4,797,270
Sunapee	-	-	5,957	5,957
Unclassified	-	4,233,041	3,562,786	7,795,827
Whitefish	130,122,000	-	-	130,122,000
Miscellaneous	-	5,363,873	651,534	6,015,407
Totals	2,586,775,857	247,809,918	23,880,997	2,858,466,772

percent were liberated as fry (table 4): this is comparable to the 93 percent listed in 1937. The remaining fish were held in the hatcheries, and about 9 percent of these fish were reared until they were 6 inches or more in size.

Although the present survey, when compared with the 1937 survey, shows some decrease in the number of fingerlings and larger fish produced, the greatest reduction appears in the number of fry produced. In general, reduction or cessation of commercial fish propagation has accounted for the decrease. The majority of fishery workers agree that artificial propagation of commercial species, both fresh and salt water, has no value in maintaining the commercial catch. Most agencies are discontinuing their propagation activities with commercial species as fast as local conditions and public opinion will allow. The liberation of fry of such species as the pikes, pikeperch, and muskellunge, is still continued in fairly large numbers.

The rearing of fish to fingerling size is much more expensive than the propagation of fry. Likewise, the longer the fingerlings are held, the greater the expense. With regard to cold-water species, such as trout and salmon, fishery workers are generally of the opinion that

use of the larger size results in a higher survival when the fish are liberated in natural waters. Many agencies with more or less stable budgets have had to reduce the number of fingerlings reared in order to liberate them at the larger sizes. This has been particularly true of trout hatcheries since the emphasis has shifted to rearing fish of legal size. Of the 23,880,997 fish reared to 6 inches or more, 85 percent consisted of various trouts, the rainbow accounting for nearly half of this total (table 5).

About 80 percent of the various species reported were reared to at least fingerling size. Trout, salmon, sunfish, largemouth black bass--in that order--made up approximately 90 percent of the total fingerling production in the United States. As in the production of legal-sized fish, rainbows accounted for nearly half of the trout fingerlings. The king salmon, or Chinook, is by far the most important of the salmon, and this is indicated by its preponderance in the fingerling production. The importance of the farm-pond program is indicated by the numbers of largemouth black bass and bluegill sunfish.

The operation of fish hatcheries that produce nearly 3 billion fish is no small task. Twenty-nine States and the Fish and Wildlife Service have reported that it would require 40 million dollars to replace their present hatchery systems (table 6). As a result of an increased number of units, alterations and remodeling during the intervening years, and the present general inflation, the capital value of State-operated hatcheries has more than doubled in the last 11 years (35 States reported in 1937; 29, in 1948).

On an annual basis, more than 10 million dollars is now required to operate the hatchery system throughout the country. This is three times the amount reported 11 years ago (37 States reported in 1937; 35, in 1948). Why the increase? When compared with the 1937 survey, the present data indicate this increase to be due primarily to an increase in the number of units operated, increased salaries, increased amount and cost of fish food, and a general increase in cost of operations. The same States did not report in each survey, but the figures submitted by the 36 States reporting in 1937 and by the 35 States reporting in 1948, together with those of the Federal agency in both surveys, indicate that there was little change in the number of persons employed and that payrolls rose approximately 140 percent.

Fish food is a major item of expenditure in trout and salmon hatcheries. Fiedler and Samson (1935) made a survey of the hatchery food problem in 1934. On the basis of replies received from 42 States, from about two-thirds of the private hatchery operators, and from the Federal Government, those writers determined that the hatcheries used annually 11,455,000 pounds of fish food valued at $608,000. Today the picture has changed greatly. With only 29 States and the Fish and Wildlife Service reporting, the food used now amounts to slightly more than 24,000,000 pounds. Thirty-four States and the Federal Government reported fish-food expenditures of $1,900,000, or more than three times the amount reported for the more extensive survey in 1934. Fish food and labor (the largest single item in the hatchery budgets) account for nearly two-thirds of the total cost of operations.

Earlier in this article the hatchery has been described as an important tool of fishery management. An equally important tool is the research devoted to maintenance and improvement of fishing throughout the country. Not until recently would administrators and the public in general accept the biologist as a necessary part of the fishery-management program. Even today, for one reason or another, many agencies have been unable to equip themselves properly with competent biologists. Considerable encouragement is given, however, by the fact that 30 States and the Federal Government are employing 324 biologists (table 7). Some States, although not directly employing biologists, contribute funds for their salaries and expenses. Thirty-four States and the Fish and Wildlife Service spend nearly 1½ million dollars annually for fishery research and management. It is believed

TABLE 6.--Costs reported by 37 States and the Fish and Wildlife Service

Source	Replacement cost of hatcheries (estimate)	Operations (Upkeep, new building, etc.)[1]	Payroll[1]	Fish food[1] Pounds	Fish food[1] Cost
Alabama	$ 125,000.00	$ 5,000.00	$ 14,484.00	30,000	$ 6,750.00
Arizona	650,000.00	99,631.75	40,821.69	350,170	21,010.16
Arkansas	279,475.00	80,000.00	30,300.00	0	0.00
California	1,500,000.00	695,964.96	303,023.21	2,353,342	141,081.02
Connecticut	109,385.00	162,582.42	36,960.49	130,000	33,262.69
Florida	115,000.00	24,808.16	-	0	0.00
Georgia	250,000.00	22,200.00	18,000.00	4,800	1,200.00
Idaho	800,000.00	-	76,600.00	-	35,080.00
Illinois	-	63,500.00[2]	84,123.46	-	300.00
Indiana	20,000.00	92,552.24	59,825.31	32,000	1,484.05
Iowa	4,500.00	65,320.52	85,000.00	-	5,200.00
Kentucky	450,000.00	14,071.67	28,460.12	-	608.02
Maine	2,500,000.00	499,035.99	93,462.00	1,300,000	81,000.00
Maryland	250,000.00	90,912.49	20,018.42	100,000	16,000.00
Massachusetts	-	25,000.00	60,000.00	900,000	75,000.00
Michigan	1,857,000.00	597,115.27[3]	299,435.00[3]	2,191,778[3]	165,000.00[3]
Missouri	-	84,144.53	40,630.00	338,000	19,135.00
Montana	-	399,743.00	88,440.94	415,470	41,547.00
Nebraska	538,900.00	97,463.03	57,468.00[4]	95,192	11,123.17
New Hampshire	-	588,040.96	84,791.03	614,666	54,978.32
New Jersey	1,250,000.00	163,396.67	52,471.88	1,100,000	95,041.63
New Mexico	28,000.00	178,267.00	46,500.00	435,067	26,628.00
New York	1,050,000.00	505,428.52	304,774.85	1,300,000	124,830.17
North Carolina	700,000.00	181,882.98	41,917.97	122,116	14,995.37
North Dakota	3,500.00	10,495.89	8,908.25	-	-
Ohio	300,000.00	113,703.19	39,813.36	0	0.00
Oklahoma	965,000.00	99,424.59	35,238.13	100,000	1,000.00
Oregon	3,200,000.00	622,000.00	262,969.00	2,225,766	174,303.76
Pennsylvania	1,790,000.00	743,072.86	276,636.88	4,095,222	312,224.64
Rhode Island	50,000.00	1,000.00	9,000.00	160,000	17,000.00
South Carolina	-	62,000.00	-	37,000	-
Texas	2,475,000.00	116,848.04[5]	61,801.33[5]	-	12,589.10
Virginia	-	179,847.95[5]	45,813.37[5]	578,760	39,915.17
Washington	4,600,000.00	1,198,258.00	354,292.00	2,929,300	152,931.00
West Virginia	775,000.00	72,696.39	35,742.59	250,358	20,109.52
Wisconsin	-	767,132.71	497,136.00[3]	-	60,000.00[3]
Wyoming	1,000,000.00	151,311.07	56,010.00	44,942	8,990.00
	27,635,760.00	8,873,852.85	3,650,869.08	22,233,949	1,770,317.79
Fish and Wildlife Service	12,383,900.00	1,621,905.00[6]	952,495.00[6]	2,040,943[6]	142,878.00[6]
Totals	$40,019,660.00	$10,495,757.85	$4,603,364.08	24,274,892	$1,913,195.79

[1] Unless otherwise noted, data are supplied for period listed in table 2.
[2] $21,500 for rescue stations.
[3] July 1, 1947 to June 30, 1948.
[4] Reported as $4,789 per month.
[5] July 1, 1946 to June 30, 1947.
[6] January 1, 1947, to December 31, 1947.

TABLE 7.--Fishing pressure, research, and farm ponds reported by 38 States and the Fish and Wildlife Service

Source	Fishing pressure[1]					Research[1]		Farm[1] ponds
	Resident licenses		Nonresident licenses		Unlicensed (estimate)	Number of personnel	Total expenditure	
	Number	Fees	Number	Fees				
Alabama	97,880	$ 97,880.00	5,264	$ 16,153.00	500,000	2	$ 5,000.00	800
Arizona	53,875	94,281.25	4,749	14,309.50	10,000	-	5,625.00	150
Arkansas	210,452	315,678.00	50,136	160,000.00	250,000	4	25,000.00	2,250
California	872,000	1,793,437.50	-	-	-	13	61,242.87	-
Connecticut	116,366	347,200.00	3,853	16,668.00	-	10	24,304.68	-
Delaware	4,562[2]	5,236.40[2]	1,543[2]	8,901.25[2]	2,000[2]	-	-	8
Florida	122,000[3]	213,500.00[3]	26,000[3]	75,723.00[3]	300,000[3]	2	8,000.00	175
Georgia	-	65,000.00	-	-	250,000	0	0.00	6,000
Idaho	143,935[4]	287,870.00	33,100	153,900.00	-	2	10,000.00	150
Illinois	585,618	585,618.00	19,080	44,886.00	-	3	34,000.00	-
Indiana	496,121	550,728.80	25,072	34,616.55	500,000	15	14,265.77	0
Iowa	313,458	265,354.95	7,341	15,508.60	115,000	3	13,000.00	10,000
Kentucky	221,208	237,596.73	17,110	20,608.60	-	7	6,730.18	25,000
Maine	97,871	97,871.00	62,463	165,528.00	100,000	4	17,570.00	75
Maryland	46,242	57,802.50	5,026	26,386.50	-	1	3,000.00	210
Massachusetts	156,774	228,007.00	5,457	15,459.25	-	1	10,000.00	15
Michigan	779,371	779,371.00	284,757	396,671.00	-	74[2]	156,570.00[2]	-
Mississippi	97,920[2]	97,920.00[2]	8,933[2]	44,659.00[2]	200,000[2]	-	-	-
Missouri	486,219[5]	1,125,030.00[5]	31,948[5]	74,728.00[5]	-	3	32,666.28	5,400
Montana	140,327	420,981.00	21,218	79,797.50	-	-	18,475.00	400
Nebraska	181,047[5]	151,629.00[5]	6,045[5]	18,741.65[5]	-	1	6,201.00	-
New Hampshire	90,918[6]	267,078.33	25,576	111,249.67	180,000	7	8,871.26	-
New Jersey	115,081	203,991.00	5,430	27,150.00	10,000	0	0.00	-
New Mexico	54,068[7]	155,572.00[7]	26,813[8]	111,943.00[8]	10,000	1	6,000.00	184
North Carolina	114,749[9,10]	168,634.50[9,10]	48,537[9,10]	79,353.00[9,10]	125,000[9]	8	14,500.00	10,000
North Dakota	47,745	19,487.90	249	695.25	30,000	-	-	500
Ohio	745,968	745,968.00	21,747	34,393.00	100,000	36	183,659.27	2,000
Oklahoma	356,023	346,023.00	8,400	39,900.00	-	2	10,843.20	75,000
Oregon	234,014	603,809.50	31,549	114,825.00	100,000	15	119,743.50	50
Pennsylvania	554,757	870,858.70	14,974	57,729.10	-	5	23,337.34	-

(Continued)

TABLE 7. (Continued)

Source	Fishing pressure: Resident licenses Number	Resident licenses Fees	Nonresident licenses Number	Nonresident licenses Fees	Unlicensed (estimate)	Research: Number of personnel	Research: Total expenditure	Farm ponds
Rhode Island	20,003	$ 34,238.40	291	$ 901.00	15,000	3	$ 7,500.00	0
South Carolina	32,038	32,088.00	1,924	13,401.00	-	-	-	600
Texas	177,295	180,791.91[3,11]	52,864	58,301.82	496,720	4	20,878.00	131,000
Virginia	229,630[3,11]	240,248.50[3,11]	13,057[3,12]	42,203.75[3,12]	-	5	5,000.00	-
Washington	270,972[13]	714,936.80[13]	14,226	31,098.00	75,000	14	95,866.00	420
West Virginia	280,000[6]	560,000.00[6]	14,442[6]	53,789.00[6]	40,000	3	11,000.00	800
Wisconsin	-	350,997.41[9]	-	498,691.93[9]	-	-	98,143.17[9]	-
Wyoming	80,051	120,076.50	25,126	173,530.00	11,441	6	25,428.16	134
Fish and Wildlife Service	8,626,558	$13,432,793.58	924,300	$2,832,399.92	3,420,161	254	$1,082,420.68	271,321
						70[9]	391,028.00[9]	
Totals	8,626,558	$13,432,793.58	924,300	$2,832,399.92	3,420,161	324	$1,473,448.68	271,321

[1] [2] Unless otherwise noted, data are supplied for period listed in table 2.
[3] July 1, 1947, to June 30, 1948.
[4] July 1, 1946, to June 30, 1947.
[5] Includes 117,074 combination fishing and hunting licenses.
[6] January 1, 1946, to December 31, 1946.
[7] Combination hunting and fishing licenses.
[8] Includes 15,812 hunting and fishing licenses @ $5, about $21,000 to fish.
[9] Includes 3 hunting and fishing licenses @ $35, about $15 to fish.
[10] January 1, 1947, to December 31, 1947.
[11] Includes 26,612 combination hunting and fishing licenses, for which no distinction between resident and nonresident is made.
[12] Includes 211,107 combination hunting and fishing licenses at $203,202.50.
[13] Includes 3,025 combination hunting and fishing licenses at $23,443.75.
Total hunting and fishing licenses sold—416,880, at $1,130,672.
Fishing considered to be 65 percent of total.

that this phase of fishery management will increase considerably in future years as its importance is more fully realized and competent biologists become available.

Since 1940, the farm-pond program has become increasingly important, not only for food production, but for creating additional fishing and relieving the pressure on other waters. Concurrently, the farm-pond program has further taxed an already overworked hatchery system by the demand for warm-water fish for stocking purposes. An attempt was made to determine the number of farm ponds, artificially constructed (table 7), throughout the country. Twenty-seven States reported a total of 271,321, which must be considered a conservative estimate. From a general knowledge of fish applications in the Fish and Wildlife Service, it appears that a lack of coordination between the State agencies and the agencies sponsoring construction of farm ponds, prevents the former from obtaining a reasonable inventory of the farm ponds within those States.

Fishermen, collectively, are a group of people who demand fishing, sponsor fishery work in the form of research, hatcheries, or other management projects, and at times encourage and stimulate the fish-culturists, biologists, and administrators in their efforts--but more often criticize and condemn them for not satisfying the demand for fishing. The pressure that this group exerts on the product of fishery management (fishing) may be measured, at least in part, by the sale of fishing licenses throughout the country. This, of course, does not indicate the total number of persons fishing, as some States do not require licenses for certain groups of their citizens--juveniles, veterans, women, and owners of private waters. Because replies have not been received from all States at this time, it is believed advisable to include table 8, furnished by the Branch of Federal Aid, Fish and Wildlife Service. Table 8 shows the progressive increase in the number of fishing licenses sold in the United States from 1932 to 1947, an increase amounting to about 160 percent for the 15-year period. In the present survey an attempt was made to secure an estimate of unlicensed fishermen. Twenty-two States reported a total of 3,420,161 (table 7). If this could be taken as a representative sample, the unlicensed fishermen in all States would number more than 7 million; this number, when combined with the total of licenses, would indicate a fishing pressure of about 20 million in this country. Or, it might be noted that the States that reported 3,420,161 unlicensed fishermen, also reported sale of 4,183,354 licenses. On the basis of a percentage figure from this and the total number of licenses sold, the total fishing pressure would amount to about 23 million. It is believed that at least 20 million people in this country enjoy fishing. The task of providing good fishing for this large group is becoming an overwhelming challenge to a very limited number of fishery workers who, in general, have limited funds at their disposal.

A break-down of personnel, as reported, is presented in table 9.

Though there has been a drastic reduction in the number of fish produced throughout the country in the last 11 years, it is believed that a wiser policy is being followed, not only in the production but also in the use to which it is put. As already mentioned, propagation which does little or nothing toward maintaining the catch--such as propagation of commercial species--is being discontinued as quickly as conditions permit. To secure greater survival, cold-water species are reared to larger sizes before liberation. It is recognized that certain conditions, such as extreme fishing pressure with limited natural reproduction and rearing conditions demand stocking with legal-sized fish; most agencies are now rearing as many of the larger fish as funds will permit. The use of warm-water species to stock waters already richly endowed with brood stock, is being curtailed as fast as information becomes available and as fast as the public can be taught that fish, like any other crop, become stunted from overpopulation. New waters, such as farm ponds and certain impoundments, require initial stocking

TABLE 8.--Fishing licenses issued in the United States

Year	Resident	Nonresident	Total licenses	Revenue
1932-1933	4,553,441	304,617	4,858,058	$ 6,775,370
1933-1934	4,602,446	253,499	4,855,945	6,586,810
1934-1935	4,710,771	410,549	5,121,320	7,009,009
1935-1936	5,277,431	555,017	5,832,448	8,002,887
1936-1937	6,254,478	667,109	6,901,587	9,309,949
1937-1938	6,751,811	684,366	7,436,177	10,220,788
1938-1939	7,111,545	746,730	7,858,275	10,837,168
1939-1940	7,131,649	799,505	7,931,154	11,227,504
1940-1941	7,151,754	852,280	8,004,034	11,617,841
1941-1942	7,501,688	921,530	8,423,218	10,731,040
1942-1943	7,283,777	744,897	8,028,674	10,024,329
1943-1944	7,208,569	621,908	7,830,477	9,840,073
1944-1945	7,522,373	757,859	8,280,232	10,580,311
1945-1946	9,975,618	1,093,099	11,068,717	15,003,796
1946-1947	11,155,766	1,464,698	12,620,464	22,667,301

The above statistics were compiled from reports furnished by State fish and game departments. The Service does not vouch for absolute accuracy of the figures, but it is felt they are the best obtainable. Owing to incomplete returns, the data for fiscal year 1940 are based upon estimates.

Compiled by Guy W. Lane,
In Charge, Apportionments and Fiscal Control,
Branch of Federal Aid in Wildlife Restoration,
R. M. Rutherford, Chief.

with warm-water fish if a desirable balance is to be established. Farm ponds which for one reason or another have become out of balance, can usually be corrected most easily by poisoning and restocking. Though some agencies stock or restock waters with fish salvaged from other waters, it is becoming widely recognized that fish secured from salvage operations may not be suitable for stocking other waters, particularly farm ponds. If a fish population is to be corrected by removal of part of the fish, it is necessary to have some idea of the total original population and the capacity of the water to support a given population. Usually warm-water fish suitable for stocking farm ponds and similar impoundments can be secured more easily and cheaply from a hatchery. Ponds stocked with small hatchery fish are more successful than those stocked with salvaged fish, as population balance can be effected more readily. It is very likely that the production of largemouth black bass and bluegill sunfish will continue at its present level for a number of years.

Writing his report on the 1937 survey, Earle stated that fish culture was then big business. The last 11 years have shown that the business has increased in some respects and that the demand for the product has also increased. As more and more people develop an urge to fish, and as living conditions for fish become further restricted by pollution, siltation, and similar detriments associated with increases in our population, the sport of fishing will tax increasingly the combined efforts of all phases of fishery management.

TABLE 9.--Personnel reported by 39 States and the Fish and Wildlife Service

Source	Administrator[1]	Fish-culturist[1]	Laborer[1]
Alabama	3	2	10
Arizona	6	8	7
Arkansas	2	4	12
California	6	126	-
Connecticut	2	12	8
Delaware	-	-	-
Florida	1	2	8
Georgia	2	0	8
Idaho	1	24	7
Illinois	1	7[2]	-
Indiana	1	0	31
Iowa	1	5	40
Kentucky	1	3	10
Maine	2	32	10
Maryland	1	3	2
Massachusetts	3	16	12
Michigan	17[3]	102[3]	36[3]
Mississippi	-	-	-
Missouri	5	12	6
Montana	-[4]	-[5]	-[6]
Nebraska	2	9[7]	15
New Hampshire	10	27	-
New Jersey	2	8	17
New Mexico	1	5	15
New York	18	-	135
North Carolina	2[8]	6	10
North Dakota	2	0	10
Ohio	2	6	15
Oklahoma	1	6	11
Oregon	3	35	15
Pennsylvania	11	73	98
Rhode Island	-	1	4
South Carolina	1	1	13
Texas	1	29	4
Virginia	1[9]	11[9]	20[9]
Washington	5	35	87
West Virginia	1	4	14
Wisconsin	-	-	-
Wyoming	3	8	19
	121	622	709
Fish and Wildlife Service	12[10]	334[10]	46[10]
Totals	133	956	755

[1] Unless otherwise noted, data are supplied for the period listed in table 2.
[2] Including 1 assistant superintendent, 5 hatchery caretakers, and 1 fish rescue station supervisor.
[3] July 1, 1947, to June 30, 1948.
[4] $4,360.
[5] $44,567.97.
[6] $39,512.97.
[7] Including 5 superintendents.
[8] In addition, 2 biologists.
[9] July 1, 1946, to June 30, 1947.
[10] January 1, 1947, to December 31, 1947.

The authors wish to thank the States for their replies to the questionnaire. It is hoped that the summary of these data, presenting an over-all picture of fish culture in the United States, will at least partly recompense these organizations for their assistance.

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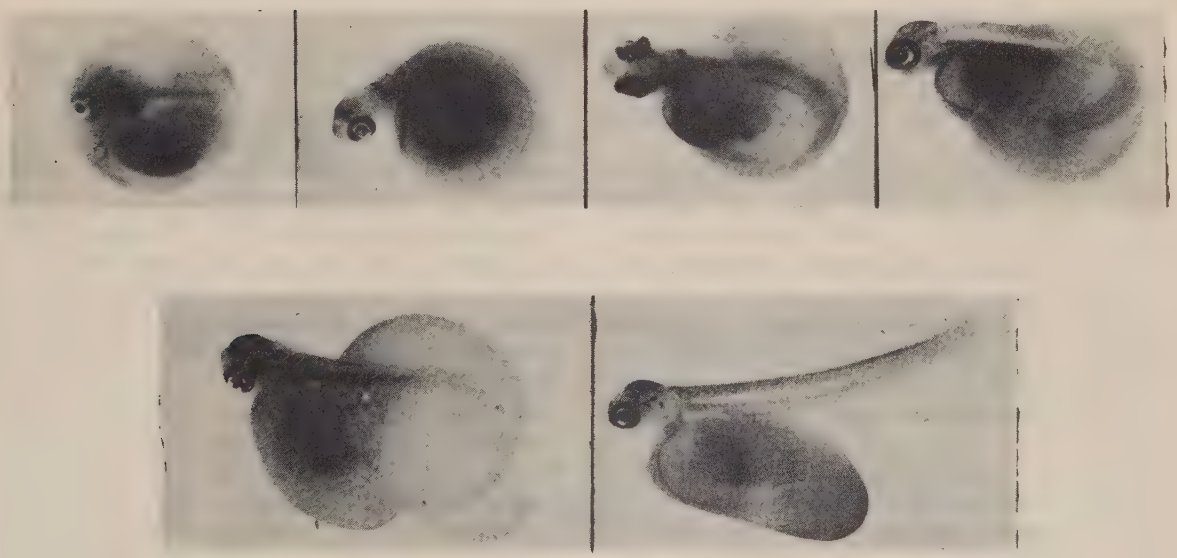

Taken at the U. S. Fish-Cultural Station at Birdsview, Washington, this is one of the few series of pictures showing the hatching of a steelhead trout.

Many fish-culturists assume that fish that hatch headfirst--like this one--will die. Is this true?

P. F. -C. LOSES

EDITOR--

Elmer Higgins

The atom bombs dropped on Hiroshima and Nagasaki have had worldwide repercussions, affecting even the PROGRESSIVE FISH-CULTURIST.

The PROGRESSIVE FISH-CULTURIST first appeared as Memorandum I-131, in December 1934, edited by Mr. Elmer Higgins, Chief of the Division of Scientific Inquiry, U. S. Bureau of Fisheries--later, Chief of the Branch of Fishery Biology, U. S. Fish and Wildlife Service. This periodical had been preceded by "Notes for the Progressive Fish Culturist" under the leadership of Dr. C. M. McCay of the Laboratory of Animal Nutrition, State College of Agriculture, Ithaca, New York.

Mr. Higgins was editor of the PROGRESSIVE FISH-CULTURIST until suspension of publication in December 1941. Recognizing the need to bridge the gap between scientific research and practical application, during these years Mr. Higgins wrote, inspired, or solicited articles--neither too popular nor too technical--designed to clarify mutual problems and contribute to better understanding between the man with the microscope and the man with the rake. When publication of the PROGRESSIVE FISH-CULTURIST was resumed in January 1947, the collaboration of the Branch of Fishery Biology and the Branch of Game-fish and Hatcheries signified the continuance of Mr. Higgins' editorial policy of coordinating the efforts of fish-culturists and fishery biologists. For the next 2 years Mr. Higgins served as an editor.

Since the first appearance of the atom bomb, atomic-energy operations have been recognized as a direct or indirect danger to wildlife and fishery resources. During "Operation Crossroads," Mr. Higgins served as liaison officer for the Fish and Wildlife Service with the Joint Army-Navy group, helping to plan and direct studies made in conjunction with the Bikini bomb tests to ascertain the effects upon fishes and other marine life in that area. Because of the need to study further the effects of atomic radiation upon living tissue, including the germ plasm, the Atomic Energy Commission and the Fish and Wildlife Service have arranged to collaborate in work programs that involve fish and wildlife studies. His training and experience have made Mr. Higgins the logical choice for liaison officer between the two agencies.

Though new duties have caused him to withdraw from active assistance with the PROGRESSIVE FISH-CULTURIST, Mr. Higgins' continued interest in the success of the periodical doubtless will lead to articles on the relation of radioactivity to our fish and wildlife resources.

Best wishes from the PROGRESSIVE FISH-CULTURIST to Mr. Higgins in this new assignment.

P. F. -C. GAINS

EDITOR-

"Fent" Carbine

The PROGRESSIVE FISH-CULTURIST welcomes as a new editor, William F. Carbine, recently appointed Chief, Section of Inland Fisheries, Branch of Fishery Biology.

The readers of the PROGRESSIVE FISH-CULTURIST have already met Mr. Carbine, whose "Bangos Culture in the Philippines" (October 1948) described some phases of his work since 1947 with the Philippine Fishery Program for the Fish and Wildlife Service.

During 1934-35 Mr. Carbine was employed by the U. S. Bureau of Fisheries for stream improvement work in Utah and for lake and stream surveys and improvement in Arizona. At the University of Utah, where he received his M.S. degree in 1936, he did research on the life history of the chub of the Great Basin. Continuing his graduate studies at the University of Michigan, Mr. Carbine undertook part-time work with the Institute for Fisheries Research. Later he accepted full-time employment with that organization, remaining there until 1947. His work on the milkfish or bangos in the Philippines involved research on growth and feeding habits, appraisal of current management, and recommendation of suitable hatchery techniques.

Publications include the following titles:

Observations on the spawning habits of centrarchid fishes in Deep Lake, Oakland County, Michigan.

Observations on the life history of the northern pike, Esox lucius L., in Houghton Lake, Michigan.

Minnows.

Artificial propagation and growth of the common white sucker, Catostomus c. commersonnii, and its value as a bait and forage fish.

Egg production of the northern pike, Esox lucius L., and the percentage survival of eggs and young on the spawning grounds.

Examples of the use of two-way fish weirs in Michigan. (with D. S. Shetter)

Movement and growth of marked northern pike (Esox lucius L.) in Houghton Lake and Muskegon River. (with V. C. Applegate)

Recaptures of tagged walleyes, Stizostedion v. vitreum (Mitchill), in Houghton Lake and Muskegon River, Roscommon County, Michigan. (with V. C. Applegate)

Fish population of Deep Lake, Michigan. (with V. C. Applegate)

Now in the Washington office of the Service, Mr. Carbine will direct research on the biology and culture of food and game fishes in our inland waters.

CONTROL OF CRAWFISH

Clay Lyle
Mississippi Experiment Station
State College, Mississippi

Six counties in the northeast prairie section of Mississippi and several in the same type area in Alabama have serious trouble with crawfish. The crawfish attack cotton, corn, and other crops during the spring, when rains are usually frequent. Control measures which have been developed for this farm land may also be applicable to the control of crawfish in pond dams and in land adjacent to fish hatcheries.

Prior to the development of DDT as an insecticide, the most practical method of controlling these pests consisted of applying to each burrow 1 to 2 ounces of a dilute emulsified coal-tar creosote stock dip. The usual dilution was 1 gallon of dip to 100 gallons of water. Best results were secured early in the spring, when the water level was near the surface and most of the burrows were open. Applications were made with compressed-air sprayers or with larger sprayers carrying several leads of hose. Because of the labor required, this method, although very effective, was not widely used on farm land. It is still a very practical treatment for burrows in gardens, yards, and pond dams, and in limited areas around lakes and fish hatcheries. To be effective, the emulsion must reach the water in the burrow. Where burrows in dams or dikes are open at the bottom into the pond or stream, it is possible for the inhabitants of the burrow to escape, or they may be out of the burrow when the treatment is applied; hence further treatments may be necessary.

Experiments during the past 2 years with DDT, benzene hexachloride, chlorinated camphene, and other new chemicals in broadcast applications, indicate that this method is effective and will be much more popular than the single burrow treatments on farm land. A. L. Hamner of the Mississippi Experiment Station has found that 1 pound of 50-percent wettable DDT mixed with 1 to 1-1/2 gallons of water and spread on 1-1/2 bushels of cottonseed per acre, will give satisfactory control, especially if broadcast just after a heavy rain. Instead of cottonseed, about 40 pounds of ground corncobs or 33 pounds of cottonseed hulls or dried silage may be used. The bait should be distributed uniformly. This treatment also is best applied in the early spring, when burrows are open and crawfish are foraging at night during rains or just after heavy rains.

The striped bass may be only half an inch long when the first scales appear, whereas the various salmons and trouts may continue "naked" until they are between 1 and 2 inches long.

URETHANE (Ethyl carbamate)

IN SOME FISHERY PROCEDURES

Shelby D. Gerking
Indiana University
Bloomington, Indiana

Weighing, measuring, and tagging or marking fish are the most common operations performed by the fishery biologist in experimental work. The quicker these operations can be performed, the better it is for both the biologist and the fish. A squirming trout or fingerling bass is hard to hold, and often the fish is squeezed unintentionally while being held for some observation. Sometimes the observation is interrupted while the fish is retrieved from the ground or a cement floor! Events of this sort may influence the results of an experiment; so it seemed advisable to inquire into the possibility of using some light anesthetic that is not toxic to fish.

No systematic search of all the possible anesthetics was made, because the first tried turned out to be very suitable. Urethane, ethyl carbamate, was selected as a possibility because it had been used as an anesthetic for fish (Hasler and Meyer, 1942) and is a common drug in physiological experiments with animals. It is a depressant of the central nervous system. Sollman (1942) reports that it "produces rapid and profound narcosis with little change in circulation or respiration," so it would seem to disturb the animal very little. The nontoxic property of urethane is unquestioned when it is used in the proper concentration, as urethane in the body is broken down to urea and carbon dioxide, both natural excretory products (Goodman and Gilman, 1941). The chemical is produced in colorless crystals which are very soluble in water.

Contribution No. 392, Department of Zoology, Indiana University.

An experiment using 0.5 percent, 1 percent, and 1.5 percent urethane by weight was conducted on a variety of fish seined from a nearby creek. Redfin shiners (Notropis umbratilis), small common suckers (Catostomus commersonii), and rainbow darters (Poecilichthys caeruleus) were subjected to the three urethane concentrations. It took between 2 and 3 minutes for the fish to become anesthetized in 0.5 percent, about 45 seconds in 1 percent, and less than 30 seconds in 1.5 percent. All recovered in about 2-1/2 minutes when placed in fresh water. In this respect, there was no striking variation among the species. When the fish were anesthetized, most of them floated at the surface, belly up. They were breathing at a regular rate, and in some the heart could be seen pulsating rhythmically. The darter and a few minnows sank to the bottom of the glass dishes in which the experiments were performed. One series of minnows, left in 0.5 percent urethane for 18 minutes, recovered in 11 minutes when placed in fresh water. Those left in 1 percent for 9 minutes died, and the same was true for minnows left in 1.5 percent urethane for 3 minutes. From these experiments it was decided to use 0.5 percent urethane for anesthetizing fish, because this concentration acted quickly enough and the fish could be left in it for at least 18 minutes without injury.

These experiments were conducted in 1946, and 0.5 percent urethane has been used by members of the Indiana Lake and Stream Survey since that time. It has been a great aid in working with large numbers of live fish which have to be handled individually. A few examples

of its use follow. Working in a hatchery, one man weighed, measured, and clipped one fin off 535 fingerling smallmouth bass in 1-1/2 hours, using 0.5 percent urethane to anesthetize the fish. These fish were transported as far as 150 miles, and only six died en route. It was possible to cover in 2 days about 400 miles on a trip to creeks where a total of 856 fish of different species were marked. They were all anesthetized with urethane, and only 15 minnows died during the operation. One gallon of the solution was used for all the fish. The chemical was also used in marking and measuring 258 rainbow trout from 7 to 12 inches long. The whole operation, including setting up the equipment and getting the fish ready to transport, took 1-1/4 hours. All the fish recovered completely and survived a 40-mile trip in excellent condition. The anesthetic has also been used to aid in tagging fish. It was particularly useful where the tag was inserted through a hole drilled in the opercular bone, which operation is practically impossible when active specimens are used. In the field it has been found that the chemical acts more quickly in warm water than in cold water.

A 0.5-percent urethane solution can be made quickly by dissolving 19 grams (2/3 of an ounce) of the crystals in 1 gallon of water. The solution can be made up in the laboratory and carried in a convenient container, or, better still, the correct amount of urethane can be weighed, carried in a small bottle, and dissolved in water when the need arises. The solution loses none of its potency if kept over a long period of time. One test showed that the solution was still effective 5 months after it was made up. Mucus from the fish sloughs off in the solution when it is in use, but this mucus can be removed by straining the solution through a crude filter. It has never been necessary to use more than 2 gallons of solution at one time. As it is used by the author, a number of fish are anesthetized, and before all of them have been handled, another series is placed in the solution. In this way observations can be made continuously.

The use of the chemical as described has been restricted to those occasions which have presented themselves to the author and associates, but it is by no means limited to these uses. In particular, another use of urethane suggests itself, although it has not been tested. Urethane decreases the oxygen consumption of animals under its influence (Sollman, 1942). For this reason it may be possible to use urethane to aid in transporting fish in hot weather. The drug will reduce the oxygen consumption of the fish in warm water where less oxygen can be dissolved and the fish are crowded. It is suggested that for this purpose less than 0.5 percent urethane be used--probably just enough to make the fish "woozy."

Those not acquainted with urethane will be pleased to learn that the cost of using it in the manner just described is very low. A late catalogue lists urethane at $3.25 per kilogram; so the cost of using 19 grams per gallon of water is only 6 cents.

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FACT AND FICTION IN SPAWNTAKING:

ADDENDA

Robert R. Rucker
U. S. Fish and Wildlife Service
Seattle, Washington

I was glad to see "Fact and Fiction in Spawntaking" by Wood and Dunn (1948) in a recent issue of the PROGRESSIVE FISH-CULTURIST. Having spent two seasons at the Yellowstone Park station, I also attempted to find ways of increasing the efficiency of fertilization and several years ago conducted a few experiments along these lines. From these experiments I obtained some "facts and fiction" that I believe are particularly germane and will be of interest to anyone who spawns fish.

I often dreamed of some Utopian technique for spawning fish--a technique that would insure 100-percent fertilization. My approach to this was an attempt to find a solution that would keep the sperm viable and active for a period of minutes rather than seconds and one that would allow eggs to remain receptive to the sperm for the same period.

The work of Ellis and Jones (1939) indicated that a solution of common salt would prolong the life of fish sperm, although the work of Schlenk and Kahmann (1938) indicated that a more complex solution must be used. I therefore tested on sperm many solutions which varied in composition, strength, pH, and temperature. None of these prolonged viability to the point where 100-percent fertilization could be expected after a few minutes' exposure at best. There was no difficulty in prolonging the fertilizable life of the egg: a plain salt solution was found quite effective, as mentioned by Rutter (1904).

In the course of my studies[1] a number of fertilization experiments were conducted. The first series of experiments was designed to determine the antagonistic effect of water, a 0.65-percent salt solution, and a Ringer's solution (6.5 gram NaCl, 0.14 gram KCl, 0.12 gram $CaCl_2$, 0.20 gram $NaHCO_3$, 0.01 gram NaH_2PO_4, and 2 grams glucose, all diluted to 1 liter) upon the fertilizability of eggs. The eggs used were taken from the landlocked form of the sockeye salmon, Oncorhynchus nerka (Walbaum), locally called the "little redfish." Eggs from a number of mature fish were thoroughly mixed and placed in a series of dry beakers with a minimum exposure to air. The milt from a number of males was collected in a dry beaker and dispensed as needed with a medicine dropper. The solutions under test then were added to the beakers containing the eggs, these were swirled, and milt was introduced at definite time intervals. The results from this experiment showed very definitely that: (1) eggs in water lose their receptivity to fertilization within a few seconds, (2) those in the 0.65-percent salt solution lose their receptivity to fertilization within a few minutes, and (3) eggs in Ringer's solution exhibit a high degree of fertilizability even after being in this solution for an hour. These results indicate the detrimental effect of water on eggs, as well as the passiveness of eggs to Ringer's solution.

A second experiment was designed to show the effect of the same three media

[1]Facilities for this work were furnished by the School of Fisheries, University of Washington. Fish were obtained from the Washington State Department of Game and the Washington State Department of Fisheries.

upon sperm. Milt was added to the medium under investigation while it was being swirled to promote complete contact. At definite time intervals, the suspension of sperm was poured over recently collected eggs. The data from this work showed that the sperm of the little redfish will live only a few seconds in water and but little longer in either the 0.65-percent salt solution or the Ringer's solution. In brief, no method for keeping sperm viable was found except storage in the semen under refrigeration. A group of 133 eggs was treated with sperm which had been held for 14 days in a covered dish in a refrigerator, and 93.2 percent of the eggs were fertilized.

The effects of various amounts of water in the spawning pan were studied in view of the results obtained in the first experiment. Eggs from the silver salmon, O. kisutch (Walbaum), were used in this work. Various quantities of water were placed in pans which contained approximately 2 ounces of eggs, and the eggs were held in the water for 2 minutes before milt was added. From the data secured it is very apparent that as the quantity of water was increased, the percent of fertilization obtained was poorer--which is in agreement with the findings of Wood and Dunn (1948). The data indicate that it is highly advantageous to eliminate all water from the spawning pans.

Another experiment provided rather general confirmation of the effect of broken eggs in reducing fertilization. The remains of 5 broken eggs were added to a group of 63 eggs prior to fertilization, and none of these eggs was impregnated. The remains of 5 broken eggs were added to a second group of 63 eggs immersed in 0.65-percent salt solution, and 52 of these eggs were impregnated. This experiment, confirming the work of Carl (1941), demonstrates that the saline solution obviates the deleterious effects of broken eggs.

An experiment then was run to determine whether a saline solution in the spawning pan would be beneficial, for, in addition to preventing coagulation of the yolk liberated from the broken eggs, the solution might act as a cushion. When eggs were dropped 18 inches into a dry beaker before being fertilized, in contrast with eggs dropped into a beaker that contained a 1-inch depth of saline solution, the fertilization obtained was 45 percent, as opposed to 92 percent. When blood was added to some green eggs before they were milted, only 60 percent were fertilized; whereas a group of these eggs washed in a saline solution before being milted showed 99 percent fertilized. All these data indicated that the presence of a saline solution in the spawning pan might be beneficial because of the deleterious effect of water, broken eggs, blood, and mechanical shock.

In large-scale hatchery operations, however, the benefits from a saline solution in spawning pans proved to be fiction in spite of the laboratory data to the contrary. The fact of the matter is (as has been demonstrated in operations at the Leavenworth, Washington, and Coleman, California, stations) that, assuming good techniques are employed in spawning operations, the use of a saline solution not only is of no benefit but may be detrimental. Why this is so, is not too clear; but it probably stems from the fact that the adverse effect from dilution of the sperm (as shown by Chang, 1946) far exceeds the beneficial effects demonstrated by the small-scale laboratory tests.

The work at the Leavenworth station was done under the direction of Mr. R. E. Burrows. Three baskets of blueback salmon, O. nerka, eggs--each basket containing about 25,000 eggs--were taken in a saline solution. The mortality to the eyed stage ranged from 2 percent to nearly 5 percent. The mortality in a similar group of three baskets of eggs carefully taken in the conventional method was between 3 percent and 4 percent. The difference between the results of the two methods is insignificant when treated statistically.

The work at the Coleman station was done under the direction of Mr. D. W. Slater. Here, about 35,000 eggs were carried in each basket and eggs of the chinook salmon, O. tschawytscha (Walbaum), were used. The mortality to the eyed stage of eggs spawned into a saline solution ranged from 2 percent to 48 percent for eight baskets. The eggs in the eight

baskets taken as the control had mortality ranging from less than 1 percent to 6 percent. The effect of a saline solution in the spawning pail was definitely detrimental in this instance.

In summary: What seemed to be fact in laboratory work proved to be fiction in actual practice.

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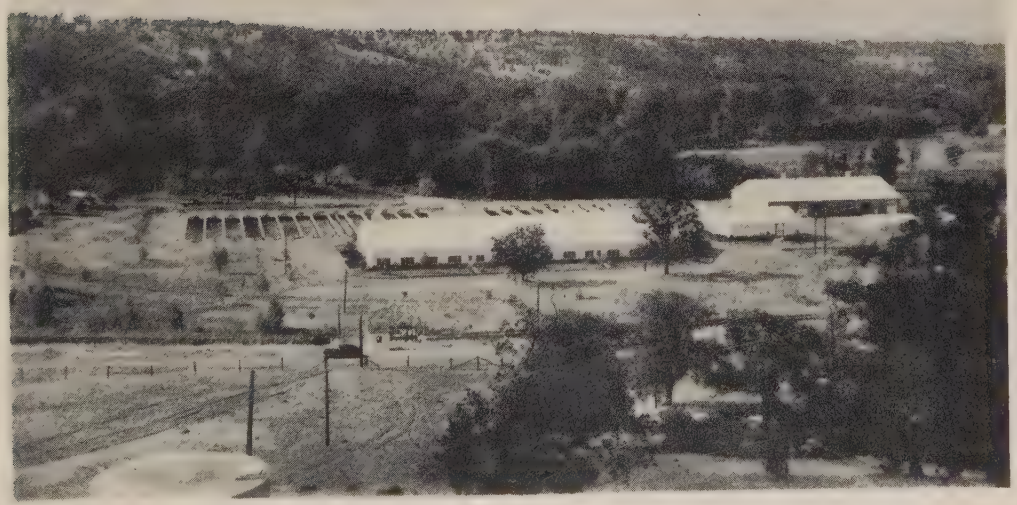

U. S. Fish-Cultural Station at Coleman, California. This is believed to be the largest producing salmon hatchery in the world. The 1947 output of fingerling Chinook salmon weighed 109,779 pounds.

USE OF LIME IN ACID PONDS

Meddie C. Walker
U. S. Fish and Wildlife Service
Cheraw, South Carolina

Early in 1948, an experiment was set up at the U. S. Fish-Cultural Station at Cheraw, South Carolina, to determine the effect of lime on water-bloom and fish production in the acid waters of the station ponds.

The pond water supply at the Cheraw station comes from a lake which, in turn, is supplied by a swampy area. The water has the typical brown color of swamp water, a pH of approximately 5.2, and no carbonates. This low pH is apparently caused by tannic and humic acids. There is little, if any, rooted vegetation in the ponds.

Six ponds, each 0.1 acre in area, were selected. Three ponds were for use with ground limestone, and three were for control without limestone. Fertilization of the ponds in both groups was identical. Ponds of both series were stocked alike with largemouth black bass and were allowed to run for approximately the same length of time.

The amounts of lime and fertilizers, and the total production of each group of ponds, may be seen in the table.

Fertilization of these ponds began on March 2 and continued at weekly intervals until six applications of 6-10-6 and two applications of cottonseed meal had been made at the rate of 100 pounds per acre. Applications of lime, at the rate of 1 ton per acre, began on March 11 and continued for 3 weeks at 7-day intervals.

Limed ponds produced a very good bloom after the second application of lime, while the unlimed ponds went from no bloom to a very light bloom. Cottonseed meal was used in the sixth application, causing the limed ponds to produce a heavy, thick, green bloom and the unlimed ponds to produce a very light bloom.

LIME, FERTILIZERS, AND PRODUCTION

	Limed ponds	Unlimed ponds
Limestone per acre	6,000	0
6-10-6 per acre	600	600
Cottonseed meal per acre	200	200
Number of bass produced per acre	28,700	28,186
Pounds of bass produced per acre	19.4	19.1

It is obvious that lime is a contributing factor in the establishment of a water bloom in such waters as we have at the Cheraw station. When the production records of the two series of ponds are compared, however, the advantage in using lime to produce larger or faster growing fish is doubtful.

EXPERIMENTAL FISH TROUGHS

S. F. Snieszko
U. S. Fish and Wildlife Service
Kearneysville, West Virginia

Experimental work on the treatment of trout diseases at the U. S. Fish-Cultural (Leetown) Station at Kearneysville, West Virginia, was limited by space and the number of trout available for experiments. At the hatchery there were 60 troughs, each 162 inches long, 13-1/2 inches wide, and 7-3/4 inches deep.

In any randomized experiment with several replications of treatments, a fairly large number of hatchery troughs must be used. As the ratio between volume of water and number and weight of fish plays an important role in the spread of infectious fish diseases, in the course of an epizootic among fish, or in the effectiveness of a treatment, it is usually necessary to have in the experiments about 1 part (by weight) of fish to 100 parts of water. Large troughs, therefore, require more fish, many of which have to be sacrificed and lost altogether. Large troughs are too wasteful of the fish which are used in the experiments on diseases and their control.

The standard hatchery troughs are arranged in two tiers, and water flows from the upper to the lower tier. In a correctly designed experiment only the upper troughs could be used: troughs of the lower tier, below the troughs used for experiments, had to be left unused or trout were exposed to contamination from the upper troughs. Therefore, experiments on trout diseases could be run only during the late spring or summer, when most of the fingerling trout were removed to the outdoor pools or raceways.

To continue experiments on trout diseases the year around and to reduce the number of trout lost in the tests, experimental troughs were built during the summer of 1947.

The experimental troughs, 24 in all, were made by partitioning each of the eight standard hatchery troughs (made of 2-inch dressed cypress boards) into three equal and watertight sections (figure 1). The inside dimensions of the experimental troughs are: length, 53 inches (134.5 centimeters); width, 13-1/2 inches (34.3 centimeters); depth, 7-3/4 inches (19.7 centimeters). The water capacity of each experimental trough is 90 liters. If water is maintained at 10-centimeter level, each trough contains 46.2 liters, and at 15-centimeter level, 69.1 liters of water. (One gallon equals 3.78 liters.) Each trough has separately regulated water-supply inlet and outlet, and water can be maintained at any desired level.

Water is supplied by galvanized-iron pipes which have an inside diameter of 1-3/4 inches. From these main pipes water is distributed to individual troughs through 1/2-inch brass gate valves and galvanized pipes of the same size (figures 1 and 2). Each trough is supplied with a simple aerator made by punching 48 holes of 1/8-inch diameter in the bottom of an aluminum baking pan, 11 by 7 by 1-1/2 inches (figure 3). The aerator is suspended between a copper wire and the upper edge of the splash guard, and is 8 inches above the edge of the trough.[1] The rate of flow is usually maintained at about 2 gallons (about 8 liters) per minute.

Spent water overflows through a drain pipe at the lower end of the trough. The drain pipe, 8 inches of 3/4-inch galvanized iron pipe, is mounted (figure 4) in a rubber stopper, size No. 10 or 11, which is fitted into the hole made in the bottom board of the trough. Because the drain pipe is mounted in a rubber

[1]Due credit is given to Mr. S. B. Friddle for the design of this simple and very useful support.

FIGURE 1.--General view of the experimental troughs. Guards are removed from two troughs at the lower left side.

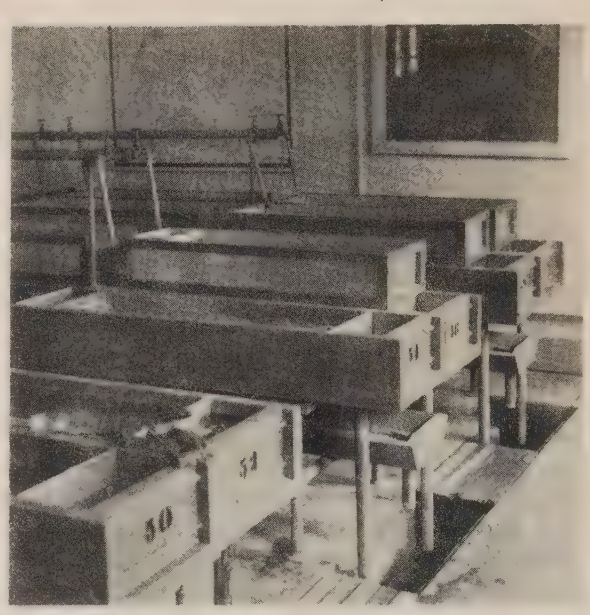

FIGURE 2.--Side view of some of the troughs. Guard is removed from trough in foreground. The draining troughs are visible under each two rows of experimental troughs.

stopper, the water in the troughs can be maintained at any desired level by sliding the pipe in the rubber stopper. For complete draining or cleaning of the troughs, pipes are removed with the stoppers. Mounting of the drain pipe in a rubber stopper also insures a tight fitting and better prevents the loss of water from troughs during experiments on prolonged treatments.

The drain pipe is separated from the remainder of the trough by an aluminum screen that has perforations of 1/8 or 1/16 inch. Screens made of 1/16-inch aluminum sheeting, 14-1/8 by 8 inches, slide into well-fitting V-shaped grooves cut in the trough walls (figure 2). The screens are placed 6 inches from the lower end of the troughs. As these experimental troughs were made by partitioning standard hatchery troughs, a separate spent-water drain had to be put under the experimental troughs (figure 2). Troughs that collect spent water should be made wide and deep enough, with perpendicular walls, to avoid overflowing water when the experimental troughs are flushed.

The experimental troughs are used chiefly for experiments on fish diseases. It is important, therefore, to prevent splashing of water and jumping of trout from one trough to another. This is prevented by placing guards over the troughs (figures 1 and 2). The guards serve also as supports of the aerators. Painted wooden frames covered with thin aluminum sheeting, the guards are 48-1/4 inches long, 15-1/4 inches wide, and 8-1/4 inches high. They rest on the top of the trough walls but do not cover the 6-inch drain sections (figure 2), which are behind the aluminum screens. Troughs can be cleaned and fish can be observed, placed into or removed from the troughs without lifting the guards.

Usually more than half of the troughs are used for experiments. The remaining troughs are used for short-term tests or for controls on the effectiveness of the routine treatments. Tests on the effectiveness of various treatments frequently furnish interesting information. When any lot of trout shows signs of disease, attempts are made to determine the cause of it. When the disease is diagnosed, a desirable number of the sick fish are distributed into some of the experimental troughs. Fish in certain troughs receive the same treatment as the main lot, fish in other troughs serve

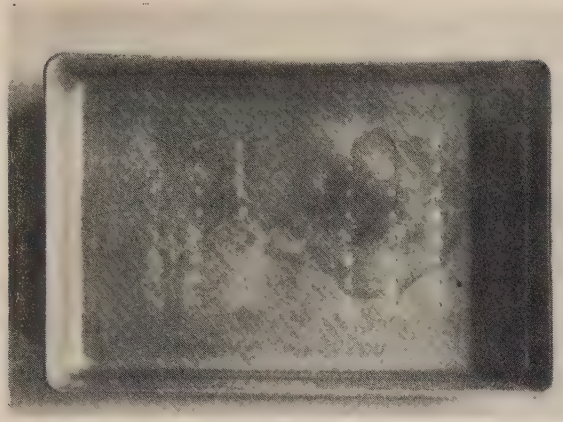

FIGURE 3.--The aerator.

FIGURE 4.--The overflow draining pipe mounted in a rubber stopper.

as controls and receive no treatments, and trout in the remaining troughs are treated with different methods or with different quantities of the drug being used. So far, experience has shown that such experiments are very interesting and often supply ideas which may be tested later in randomized experiments conducted with a statistically sufficient number of fish. Such tests of the routine treatments are even more useful when the cause of the disease has not been determined. Quickly made trial treatments on small numbers of fish help to select the most promising treatment for the main lot of the diseased fish.

The writer believes that each large fish hatchery should have several small testing troughs built on the same general principal as the experimental troughs here described. Upon occurrence of a fish disease which cannot be diagnosed by the superintendent, and before outside help is available, certain numbers of the diseased fish should be evenly distributed among the testing troughs and treated with several well-established methods. One trough should be kept as control. Control is very important. On several occasions the writer observed that the untreated trout recovered as well as the treated. At other times most of the control fish were lost and the treated fish recovered completely. Observations made by superintendents should be carefully recorded and reported to the chief pathologist, who should evaluate the significance of the tests.

Many small tests made all over the country, well analyzed and critically evaluated, should supply a wealth of information and ideas which in due time could be tested properly at the experimental stations. In order to encourage superintendents to make the tests, due credit should be given to all who contribute any well-conducted and reported tests.

Most anglers who have had their pet offerings refused by some wily trout, will heartily endorse the conclusion of anatomists--that the brain of the trout is dominated by the optic area.

NEUTRALIZING CHLORINE IN TROUT DISPLAY TANKS

E. O. Rodgers
U. S. Fish and Wildlife Service
Cortland, New York

For several years I was in charge of displays of live fish for the Fish and Wildlife Service at the various sportsmen's shows in the East. We had the problem of keeping fish alive in city water, which had been chlorinated, for periods of about 10 days at each show. In the beginning it was not uncommon for us to have to replace the fish after 2 days, and even before that time there were often serious losses not only among our fish but also among fish of other exhibitors, and frequently entire lots would die before the show was completed.

To keep fish alive and active, we tried introducing sodium thiosulphate into the tanks to absorb the chlorine of the city water. The method was almost 100-percent effective, and losses became negligible. One season we used a group of trout for 10 days at one show, returned them to the hatchery for 3 days, and then transported them almost 300 miles and put them through another 10-day exhibit--and had every fish alive at the end of the show.

This was not set up as an experiment: it was simply an attempt to keep fish alive, and no test of the water was made to determine the amount of chlorine originally present or how much reagent was necessary.

To introduce the reagent into the aquarium, the following method was used: A 5-gallon carboy was set up behind the exhibit. A rubber tubing was run from the water supply line and connected to one opening of a two-hole rubber stopper in the carboy. Another rubber tubing was attached to the other opening in the stopper and run to the aquarium containing the fish. Flow of the treated water from the carboy was controlled by means of a pinchcock on the rubber tubing leading to the aquarium. A quantity of sodium thiosulphate ("hypo") was placed in the carboy and renewed when necessary, depending upon the action of the fish.

The amount of chemical put into the carboy is unimportant if the drip of treated water entering the tank is regulated to suit the comfort of the fish. If the solution is too strong, it is necessary only to reduce the volume of the drip. A valve of some sort should be used on the carboy supply line to prevent pressure from blowing the stopper. The drip should not be introduced too near the intake or outlet but somewhere near the center of the tank or aquarium. This seems to provide an area where the fish can find conditions to their liking. If the reagent is coming in too strong for the fish, they will move to an area somewhere between the flow of water containing chlorine and the point where the chemical is being introduced. It has been observed that the fish change their position at different times after the carboy has been charged. Soon after new chemical is put in, they move away from the drip; as the charge becomes weaker, they move back to the place where the reagent is coming into the tank.

A method simpler than that already described was used for the last seven exhibits which we prepared. We simply took baking-powder or similar tin cans with covers, punched a number of holes in top and bottom of each, put the chemical in the cans, and submerged them in the aquaria about midway from the ends. Before placing these cans out of sight behind some of the stones in the aquaria, we attached a string to each can. This string, brought over the top of the tank in back, permitted the can to be removed easily for refilling and provided a means of shaking the can a bit if the action

of the fish indicated that too little for the comfort of the fish was being dissolved into the water. These cans were refilled morning and evening, about a double handful of the "hypo" being used each time. The chemical was used in much smaller quantity than in the drip method described and was equally effective. In the last seven shows which we exhibited, we did not lose a single fish. Where an exhibit had to be moved from place to place, these cans were much easier to handle than the glass carboys.

Where a large display of fish is held for some time, it would be possible to determine the concentration of the chlorine and then to measure the amount of the reagent necessary to neutralize the chlorine. The drip of treated water could then be calibrated. Very good control should be possible as long as the supply water is watched for changes in amount of chlorine present. The sodium thiosulphate can be purchased very reasonably from camera supply places and drugstores.

U. S. Fish-Cultural Station at Creston, Montana.

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FROM PUBLICATIONS

REPRINT

NEW INDUSTRY IN UTAH UTILIZES TRASH FISH

Earl Lloyd's crew unloading trash fish at Strawberry Lake.

A new industry recently springing into existence in Utah is of particular interest to sportsmen inasmuch as it pertains to the use of trash fish. The Utah Processing Company has constructed a plant on the shores of Deer Creek Reservoir near Charleston, Utah, and is just beginning to process trash fish. Although yet in the experimental stages, it shows promise of benefiting the state of Utah in a number of ways.

The plant, installed at a cost of $60,000.00 is capable of handling about 10 tons of trash fish per hour. The machinery in the plant consists of large rotary steam cookers, presses, dryers and grinder. The trash fish consist of carp, chubs and suckers seined from nearby waters inhabited by these fish. The rough products include fish food both green and dry, poultry food, to be used at mink and fox farms and fish oils.

The processing of the trash fish is of first concern to the game department inasmuch as securing an ample supply of food for our fish hatcheries is rapidly becoming a major problem. In recent years the number of horses used on farms has decreased very rapidly and at the same time there has been a great demand for horses to furnish food for fur farms and much has gone into the production of dog meat. The viscera and other waste products of slaughter houses have not furnished nearly enough fish food to meet the demand

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Nine and one-half tons of trash fish caught in seine haul at Strawberry Lake.

of our hatcheries. The fish meal and also the green fish produced at the plant at Charleston are eyed with more than a general interest by our fish hatchery men. In the past some trouble has been experienced by feeding too much fish at our hatcheries. It is believed much of the trouble encountered in the past will be overcome now inasmuch as all the oils are removed at the processing plant.

Aside from the fact that the processing of the trash fish may mean more food for the fish at our hatcheries there is real interest in the removal of undesirable species in the fishing waters of Utah. We recognize the fact that there is room for only so many animal units for any given area. If in any case a given habitat, say Deer Creek Reservoir, is more conducive to the welfare of common fish than it is for game fish, that species will flourish to the detriment of more desirable varieties. In many cases the competition for food may even become a factor. Common fish have become so numerous in some lakes that trawlers and even fly fishermen are greatly annoyed with undesirable fish taking their lure. It is not expected that the seining and processing operations will eliminate the undesirable fish from Utah's lakes, but it should tend to improve the conditions. Already more than 100 tons of fish have been removed from Strawberry Lake.

The poultry industry will benefit immensely with the production of large quantities of this rich food. It is reported the meal made at this plant contains about 65 per cent protein matter. Many uses are made of oils pressed from the trash fish. At present much of the oils processed by plants of this kind are used by Proctor and Gamble Co. Immense quantities go into the manufacture of cosmetics, and paints. Oil of this nature is also used extensively in the tempering of steel. There is an increasing demand for this product.

The water that is pressed from the fish is also of value. It is highly impregnated with vitamins, and is used in the manufacture of oleomargerine; at present time, however, there is no method provided at the Charleston plant to make possible the processing of the body water.

Local farmers will have the opportunity of securing some of the very best fertilizer that can be found by using body water.

ABSTRACT

AMERICAN FISHERIES SOCIETY

THROUGH the courtesy of Dr. Ralph Hile, Chairman of the Editorial Board, we have been permitted to present the following abstracts of papers prepared for the 78th Annual Meeting (September 13-15, 1948) of the American Fisheries Society:

EFFECTIVENESS OF MODERN FISH MANAGEMENT PRACTICES: PLANTING

Lloyd L. Smith, Jr.
University of Minnesota
St. Paul, Minnesota

Extensive hatchery operations with commercial fresh-water species have failed to influence the volume of subsequent commercial catch. Critical analysis indicates that the survival of these plantings has usually been at the expense of native reproduction, which far exceeds hatchery production. Hatchery-reared warm-water species have given satisfactory results in waters where desirable species did not already exist, but efforts to increase fish production in natural bodies of water that contained adequate spawning stock have frequently caused overcrowding, and plantings have been equally futile in waters that primarily required environment improvement. Plantings of fingerling trout in streams have not improved fishing significantly, except where there were no natural facilities for reproduction or where heavy fishing reduced brood stock below the minimum required for adequate reproduction. Plantings of catch-sized trout are very expensive; they are economically justifiable only where the undertaking can be made self-supporting on intensively managed areas. More effective use of the present inadequate license fees on a State-wide basis would involve improvement of trout habitat, including soil control, pollution abatement, and physical adjustment of the stream channel.

REPORT OF THE DIVISION OF FISH CULTURE

O. R. Kingsbury
New York Conservation Department
Albany, New York

The modern fish-culturist seeks to increase production and decrease operating expenses while maintaining the quality of his product and meeting the stocking needs of the area served. The productivity of a hatchery can best be evaluated in terms of pounds of fish produced annually per cubic foot of water in rearing space and pounds of fish produced annually per gallon flow of water per minute. By these criteria it is possible to determine the effectiveness of hatchery management measures. In 1943-44 the Bath hatchery produced 27,000 pounds of trout at about 80¢ a pound, an output that represented 1.25 pounds per cubic foot of rearing space and 25 pounds per gallon per minute flow; in 1946-47, however, improved feeding and management techniques permitted the saving of about 8¢ a pound in the production of 44,139 pounds, an average of 2.1 pounds per cubic foot of rearing space and 42 pounds per gallon per minute flow. Remodeling of the hatchery unit at Warrensburg increased production from 4,891 pounds (2.62 pounds per cubic foot of rearing space, 14.25 pounds per gallon per minute flow) in 1943-44, to 13,482 pounds (3.07 pounds per cubic foot of rearing space, 40 pounds per gallon per minute flow) in 1947-48. The trout hatchery at Cold Spring Harbor, which needs redesign to bring the flow of water and

the rearing capacity into proper relationship, during the 1943-44 period produced but 3,937 pounds of trout (0.06 pound per cubic foot of rearing space, 9.6 pounds per gallon per minute flow); whereas, through modern management techniques--the elimination of all brood stock, the use of a disease-resistant strain of fingerlings, the use of sulfadiazine in disease control, and replacement of two old artesian wells with two new wells--in 1947-48 the unit produced 13,693 pounds (0.198 pounds per cubic foot of rearing space, 27.4 pounds per gallon per minute flow), which represented an increase of approximately 222 percent and resulted in a saving of 51 percent in operating costs.

REPORT OF THE DIVISION OF AQUATIC BIOLOGY AND PHYSICS

Paul R. Needham
Oregon State Game Commissior
Portland, Oregon

Closer cooperation on the part of the State fish and game administrators and the research worker, particularly in the State educational institutions, would be decidedly advantageous to both groups, as well as to the general public. Effective management of our fishery resource will depend largely upon wise use of hatchery-reared fish, fertilization, and habitat improvement, as well as upon adequate fishing regulations based on biological data. The increasing use of powerful insecticides and herbicides makes it imperative that we have careful studies of the long-time effects of these materials upon the ecology of our waters. Further, evaluation and protection of the fishery resource should be an integral part of the extensive water-development programs now directed largely in the interests of flood control, power, irrigation, and navigation: each project should be studied and approved or rejected by an unbiased board of experts selected from every field concerned.

OBSERVATIONS ON THE SPAWNING HABITS OF THE LAKE TROUT (Cristivomer namaycush namaycush) IN AN ALGONQUIN PARK LAKE

N. V. Martin
Ontario Department of Lands and Forests
Toronto, Canada

Observations on the spawning habits of the lake trout were made in Lake Louisa, Algonquin Park, late in October and early in November of 1947.

Spawning beds were characteristically located on exposed shores facing the prevailing winds. The bottom was clean rubble. The trout moved to the beds at dark, and most had left before midnight. Male trout, particularly the smaller, were the first to move to the spawning areas in the season; the males also arrived first in the daily migration from deeper water.

Courtship was frequently noted, but the actual spawning act was not seen. The spawning period lasted about 2 weeks. Eggs were recovered from depths of 8 inches to 4 feet. The lake trout fed throughout the spawning period.

STUDY OF THE COEFFICIENTS OF CONDITION OF WILD BROOK TROUT FROM THE UPPER HUNT CREEK DRAINAGE, MICHIGAN

David S. Shetter
Michigan Department of Conservation
Ann Arbor, Michigan

Coefficients of condition were calculated for 4,506 brook trout taken by angling from the Hunt Creek drainage between 1939 and 1945. The formula used was $K = \frac{W \times 10^5}{L^3}$, and weights were measured in grams and total lengths in millimeters. The data were sorted by 10-millimeter size groups, week of the trout season and year, and averages of K values obtained for each sorting. A table of conversion factors was made to enable other workers to convert the K values obtained from total length measurements to K values based on corresponding standard length measurements. For the period 1939-1945, the following grand average values of

K were found for angler-caught brook trout above 178 millimeters in total length: Hunt Creek, K = 0.931; Fuller Creek, K = 0.908; Fuller Creek Beaver Pond, K = 1.046; East Fish Lake, K = 1.074. During the early weeks of the trout season, in late April and May, coefficients of condition were usually well below the grand average, but by mid-June and July the peak of condition was reached. There appears to be a slight retrogression in condition late in August, when analysis of the averages of the K values for the various 10-millimeter size groups indicates that in general larger fish are in better condition than the smaller fish. Considerable fluctuation between the yearly averages was noted.

Individual weights and measurements on 29 female brook trout and 48 male brook trout (all tagged) shortly before and shortly after the conclusion of the spawning act, revealed that reproductive activities decreased the K values of female fish an average of 21.8 percent, of males, 15.5 percent.

During the calendar year 1941, from 10 to 182 brook trout were measured and weighed alive each month, and 1,275 sets of measurements were obtained. The averages of the monthly K values obtained from these data indicate that the brook trout of Hunt Creek are in their poorest condition during January, February, and March, but rapidly reach near-peak condition during April, May, June, and July; this is followed by a decrease in average K values in August. By October they reach a level of condition similar to that noted for the early summer months, but they drop back to a low level of condition after the spawning season.

Some confirmation of the seasonal fluctuations observed in the 1941 data is provided by K values obtained from 284 brook trout measured, weighed, and tagged in April, July, and September, 1945, and by 470 subsequent recoveries when weights and measurements also were obtained. Also presented are some data which suggest that jaw-tagging was not a factor in the changes of K values noted.

Measurements of length, weight, and weight of gonads from 46 male brook trout and 70 female brook trout provide a basis for estimating the percentage of K made up by the gonads at various times of the summer and fall.

Data on 65 brook trout from East Fish Lake, including sex, length, weight, weight of gonads, and relative fullness of stomach, provide some indication of the effect of fullness of stomach on K values.

Coefficient of condition among the brook trout of the Hunt Creek drainage appears to be affected by habitat, season, size of fish, state of sexual maturity, and fullness of stomach at the time length and weight measurements are taken. The study indicates that there can be a considerable variation in condition within a segment of the population at any one time. For this reason, an adequate series of lengths and weights taken at the same time from all size groups present is highly desirable.

OBSERVATIONS OF SMELT SPAWNING, SOUTH BAY, MANITOULIN ISLAND, 1948

N. S. Baldwin
Ontario Department of Lands and Forests
Toronto, Canada

A smelt fishery established on the streams and freshets flowing into South Bay yielded a total of 51,382 pounds to local fishermen using dip-nets and seines. The age composition of the catch and the average lengths attained by the spawning age groups were determined. This information and some general observations on the spawning behavior of the smelt are presented.

MOVEMENTS OF QUEBEC SHAD AS DEMONSTRATED BY TAGGING

Vadim D. Vladykov
Quebec Department of Maritime Fisheries
Quebec, Canada

During 1945-48, 1,855 shad were tagged and released in the St. Lawrence River, Quebec. Although the number of returns

was rather small (about 0.6 percent), recaptures of 41 tagged shad are of a particular interest. The movements of 37 fish, tagged principally at Green Island, indicate clearly that Quebec shad, after spending winter months in the Atlantic, ascend the St. Lawrence River in May and June. The daily speed of these fish was from 25 to 50 miles. During July and August, spent shad started to leave Quebec waters. Four recaptures outside Quebec were as follows: one, around October 1, 1947, at Provincetown, Mass., after being in the water 445 days; one, on March 30, 1947, at Browns Bank, N. S., after 232 days; one, in Cumberland Basin (Minudie, N. S.) on June 27, 1946, after 323 days; and one, on May 31, 1948, at the Atlantic side of the Canso Strait (Arichat, N. S.) after 327 days. The longest period in water previous to recapture was that of 706 days, and the maximum distance traveled was more than 1,200 miles.

RATES OF GROWTH OF GAME AND PAN FISH IN OHIO, THEIR PRACTICAL INTERPRETATION AND SOME TECHNICAL PROBLEMS INVOLVED

Irene M. Evans
Ohio University
Athens, Ohio

Scales of more than 2,000 fish from nearly 75 different lakes in Ohio were examined. Species of fish from which scales were studied included largemouth black bass, black and white crappies, and bluegills.

Growth determinations correlated closely with population studies, particularly so in those lakes wherein crowding was evidenced and where populations were small and space was still unlimited (i.e., new lakes). Absent or limited year groups were also disclosed.

Whereas the annuli appear to be year marks, the date of their formation is decidedly not uniform. Annuli have been found forming from March into August in the different species, different sizes and different lakes in the State.

Further laboratory and field studies are being made to "fix" these dates.

CHANGES IN GROWTH RATES OF FISHES FOLLOWING REDUCTION IN POPULATION DENSITIES FOLLOWING WINTERKILL

William C. Beckman
Michigan Department of Conservation
Ann Arbor, Michigan

Studies were made on four lakes to determine the effect of the reduction in numbers by winterkill. Earlier studies had indicated that reduction in population densities had a marked effect on the rate of growth. Scale samples and counts of dead fish were obtained at the time of the winterkill in 1945. An increase in the rate of growth too great to be accounted for by annual variations, was found in all but one species in one lake. However, the increase in growth rate was not maintained for longer than 1 year in most species. Further studies are to be made to determine possible methods which would increase and maintain the greater rate of growth.

THIRTEEN-YEAR RECORD OF FISH PRODUCTION FROM MEANDER LAKE AND ACCOMPANYING VARIATIONS IN FISH POPULATIONS

Lee S. Roach
Ohio Division of Conservation and Natural Resources
Columbus, Ohio

Meander Lake is an artificial lake of 2,010 acres in which no angling is permitted, but from which the Ohio Division of Conservation has removed fish by trap net annually.

The lake was filled in February 1932. It was stocked in 1934 with approximately 6,000 adult fish (about 100 largemouth bass, 800 bluegills, and the remainder crappies), in the fall of 1935 with 1,700 gizzard shad, and in the spring of 1940 with 400 white bass breeders.

Removal of fish by our nets began in the fall of 1935. In 1938 nets were used during the spring and fall, and since 1939 only in the spring (prior to spawning). An average of 16 pounds of fish was removed from each acre annually. About 3 percent of these were largemouth

bass; 5 percent, bluegills; and more than 70 percent, white crappies. Bass and bluegill removal averaged nearly 10 percent each of the total catch for the first 5 years; then crappies increased rapidly to reach a peak in 1940. Since then, crappies have gradually decreased, and in 1948 white bass constituted the major catch of the lake.

Size of the different species varied through the years and in some cases appeared to be correlated with the number removed.

FISH DEPTH DISTRIBUTIONAL STUDY OF TYGART RESERVOIR, WEST VIRGINIA

E. A. Seaman and Robert F. Stephens
West Virginia Conservation Commission
Charleston, West Virginia

Two summers of study (1947-48) of Tygart Reservoir (a flood-control dam), near Grafton, West Virginia, show a definite depth distribution of fishes during the warmest months. Although sufficient data are not yet available, there is indication from present information that changes to warmer water temperatures cause greater depth distribution of the fishes. The reservoir has been opened to year-round fishing on an experimental basis. Miscellaneous limnological data are presented. Gill nets were used for catching fish.

GROWTH STUDIES ON FISH: THE USE OF HYDRAULIC PRESSES IN MAKING SCALE IMPRESSIONS

John T. Greenbank and D. John O'Donnell
Wisconsin Conservation Department
Madison, Wisconsin

There is described in detail, with photographs, the construction and operation of a hand-operated, hydraulic-powered, heated die press, as well as an electrically operated, foot-control, hydraulic-powered, thermostatically controlled, heated die press. The presses are used to prepare impressions of fish scales on cellulose acetate for use in growth studies. The method of using acetate impressions provides a marked saving in time, materials, and storage space, and produces better definition upon projection.

FERTILIZATION OF NATURAL LAKES IN MICHIGAN

Robert C. Ball
Michigan State College
East Lansing, Michigan

Inorganic fertilizer was applied to two State-owned lakes in northern Michigan, one a 4.3-acre trout lake and the other a 27.5-acre warm-water lake. Nearby two similar lakes were kept under observation as controls.

Fertilizer brought about a plankton-algae bloom the first summer in the warm-water lake and produced a very heavy growth of filamentous algae the second summer. The trout lake responded much less to the added nutrients, and the reading of Secchi's disk was at no time less than 8.2 feet.

No appreciable oxygen depletion occurred the winter following the first season of fertilization. Chemical analysis in February of the second winter showed severe oxygen depletion, with oxygen levels at less than 1 p.p.m. at all depths, and an almost complete winterkill occurred in both fertilized lakes. No winterkill occurred in the two lakes serving as controls.

FISH REMOVAL IN AN EFFORT TO INCREASE THE GROWTH RATE OF FISH IN IMPOUNDED WATERS

John D. Walker
Ohio Division of Conservation and Natural Resources
Columbus, Ohio

A fish-removal program was carried on for 61 days during April, May, and June in Kiser Lake, a 400-acre artificial lake, in an effort to reduce the large population of small white crappies and to increase the growth rate of the fish

in the lake. In 61 days, 116,609 fish weighing 16,130 pounds were removed.

Test net data for June 1947 show that 96 percent of the white crappies were 5 to 6 inches in length; 2 percent were 6-1/4 to 7 inches; 1 percent were 7-1/4 to 8 inches; and 1 percent were 8-1/4 to 14-1/2 inches in length. July 1948 test net data show that 9 percent were 5 to 6 inches in length; 67 percent, 6-1/4 to 7 inches; 22 percent, 7-1/4 to 8 inches; and 2 percent, 8-1/4 to 12 inches long. In June 1947, the dominant length groups were 5-1/2 and 5-3/4 inches. In July 1948, the dominant length groups were 6-3/4 inches and 7 inches, with increasing numbers measuring between 7-1/4 and 8-3/4 inches in length.

VALUE OF VARIOUS SULFONAMIDES IN THE TREATMENT OF FURUNCULOSIS IN BROOK TROUT (Salvelinus fontinalis)

S. F. Snieszko, J. S. Gutsell, and S. B. Friddle
U. S. Fish and Wildlife Service
Kearneysville, West Virginia

In 1945 sulfamerazine was found most effective in the treatment of furunculosis. Sulfadiazine and sulfanilamide, tried late in the experiment, did not seem very helpful; but sulfathiazole, tried throughout the experiment, was markedly beneficial. Since then, sulfamethazine has been recommended for a wide range of bacterial diseases.

In this experiment, sulfamethazine, sulfathiazole, sulfamerazine, and sulfamerazine alternated with sulfathiazole, were compared in the treatment of furunculosis among yearling and fingerling brook trout in 1947. The daily dosage rate for sulfamerazine (Gutsell, 1947; Gutsell and Snieszko, in press) and sulfamethazine was 6 grams per 100 pounds of fish (13.2 grams per 100 kilograms); for sulfathiazole (cheaper but less effective than sulfamerazine), 12 grams per 100 pounds. The drugs were thoroughly mixed with the food.

The courses of the epizootics were very different in the 2-year classes. With the yearlings (28 days), mortalities were as follows: controls, 100 percent; sulfamerazine, 29 percent; sulfamerazine-sulfathiazole, 43 percent; sulfathiazole, 75 percent; sulfamethazine, 62 percent. With the fingerlings, mortality, although finally heavy in the controls, was much less acute and sulfonamide therapy was very much more effective. Mortalities were as follows: controls, 89.9 percent; sulfamerazine, 7.6 percent; sulfamerazine-sulfathiazole, 5.5 percent; sulfathiazole, 11.4 percent; sulfamethazine, 5.1 percent.

Important was the revelation of the extreme difference in the courses of the epizootics and the apparent correlation of effectiveness of treatment with the type of epizootic. However, prompt initiation of treatment may largely explain the great effectiveness of the various drugs with the fingerlings.

As in 1945, sulfathiazole was markedly inferior to sulfamerazine. Sulfamethazine showed considerable promise and warrants further trials. Sulfamerazine still seems the best in an acute epizootic.

PROPHYLAXIS OF FURUNCULOSIS IN BROOK TROUT (Salvelinus fontinalis) BY ORAL IMMUNIZATION AND SULFAMERAZINE

S. F. Snieszko and S. B. Friddle
U. S. Fish and Wildlife Service
Kearneysville, West Virginia

The oral immunization of trout against furunculosis was investigated by Duff (1942). He reported that mortality caused by furunculosis in cutthroat trout (Salmo clarkii) infected by feeding virulent culture of B. salmonicida was markedly reduced by previous, prolonged oral immunization.

The purpose of our experiments (which were suggested by Dr. C. M. Mottley) was to try the prophylactic value of oral immunization under normal hatchery conditions. Fingerlings of brook trout, which are very susceptible to this disease, were tried in two series of tests.

Oral immunization with killed suspension of B. salmonicida was started in February. One day each week the immunized trout were fed food containing the antigen. For about a week before infection,

antigen was administered daily.

In the first series of tests conducted in June, the immunized trout were infected either by feeding or by injecting parenterally a suspension of living B. salmonicida. All the orally infected trout, including not immunized controls, survived. From the parenterally infected trout, all the trout infected with a diluted suspension of bacteria survived and all trout infected with concentrated solution died in controls and orally immunized lots.

In the second series of tests conducted in July, the immunized and control trout were infected only parenterally with three different concentrations of B. salmonicida. All the infected, orally immunized trout died, and no beneficial effect of oral immunization was noticeable.

The effect of the prophylactic value of oral immunization was compared in both series with the prophylactic value of treatment with sulfamerazine. Food containing sulfamerazine was fed to the experimental trout once every week for several months, and daily for several days before infection and during the observation period. Sulfamerazine had no effect in the trout infected with a heavy suspension of B. salmonicida. Mortality was somewhat reduced in trout infected with medium-heavy bacterial suspension. There was a clearly beneficial effect on the survival of trout infected with a diluted suspension of B. salmonicida.

A CONTRIBUTION TO THE ETIOLOGY OF ULCER DISEASE OF TROUT

S. F. Snieszko and S. B. Friddle
U. S. Fish and Wildlife Service
Kearneysville, West Virginia

Ulcer disease was described by Calkins (1899), Fish (1934), and Wolf (1938, 1940). The etiology of this disease remained unexplained.

In the fall of 1947 there was an outbreak of ulcer disease among brook trout (Salvelinus fontinalis) at the Leetown Station. The symptoms of the disease were typical. Treatment with sulfamerazine failed to control the disease.

From the blood, tissues, and lesions of most of the affected trout, B. salmonicida was isolated in what appeared to be a pure culture. In further bacteriological studies, very small, hardly visible colonies grew on media inoculated with blood of the diseased trout. Sometimes these colonies were in pure culture, but usually colonies of B. salmonicida were also present.

Further cultivation of the bacteria present in the small colonies was possible only in media with added fish or rabbit blood. Later good growth was obtained on media to which had been added sterilized (by filtration) water extract of trout tissues. This bacterium was isolated in pure culture also from several brook trout fingerlings, or yearlings, brought from other fish hatcheries.

In several experiments brook, brown, and rainbow trout fingerlings were inoculated by parenteral injection of the pure cultures of this newly isolated bacterium. In all cases, infection occurred with heavy mortality. As all brook and brown trout used in the experiments originated from lots having a history of furunculosis, when reisolated the new bacterium was often--but not always--accompanied by B. salmonicida. From the inoculated rainbow trout, originally free from furunculosis, the new bacterium was regularly reisolated in pure culture.

The new bacterium is a gram negative rod, nonmotile, facultatively anaerobic but growing better aerobically. It does not liquefy gelatin nor produce changes in litmus milk. It ferments some sugars with the production of acid but no gas. It can be propagated only on media containing fresh blood (or sterilized by filtration) tissue extracts.

ATOMIC ENERGY AND FISHERY AND WILDLIFE RESOURCES

Elmer Higgins
U. S. Fish and Wildlife Service
Washington, D. C.

Because of the rapid spread of the use of radioactive substances in biological,

medical, agricultural, physical, and industrial research, and because of the probable development and application of atomic power for industrial purposes, we must learn all we can as soon as possible about radioactivity and its relations to everyday life.

Natural and manufactured radioactive elements emit invisible, powerful, and penetrating rays capable of changing profoundly the structure and behavior of all matter. The principal rays, the alpha, beta, and gamma rays, differ in character, energy, penetrating power, and consequent effects and uses; but all of them, either directly or indirectly, ionize the atoms or particles of the material through which they pass.

This power of producing ionization is the characteristic of atomic radiations of greatest interest to biology, medicine, agriculture, and conservation; for ionization of the tissues of living things may derange life processes and destroy cells or structures, resulting in immediate or later death of the organism, or it may prevent reproduction or so change the germ plasm as to alter the physical characteristics of species.

The Atomic Energy Commission has spent great sums and effort in research and in practical and successful measures to promote the useful employment of radioactivity and to prevent the spread of damaging radiation.

There is no evidence that atomic-energy operations constitute a grave or immediate danger to wildlife resources. More time must elapse before we can evaluate long-time low-level radiation effects which may manifest themselves in a slightly reduced rate of reproduction of wildlife species or in an increased rate of mutation.

In carrying out the provisions of the Atomic Energy Act, the A.E.C. is interpreting broadly its duty of supporting and promoting research in the basic sciences. It has established training programs in radioactive techniques, it is awarding fellowships to a considerable number of research workers at universities and Commission laboratories, and it is producing and widely distributing isotopes for research. And finally, in our own field, cooperative projects are being established by the Commission and the Fish and Wildlife Service for the study of wildlife problems.

Radioisotopes offer a new and powerful tool of research as tracers in life processes and even perhaps in population studies of wildlife. New advances in the more theoretical fields of biology and medicine made by these means will have their effects in conservation. Plans are under way for applying these new methods to research on fishery and wildlife problems.

CLEARING HOUSE

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(Edwards Brothers, Inc., Ann Arbor, Michigan.)

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